WL-TR-91-3112

T-38 FORWARD WINDSHIELD DEVELOPMENT AND PERFORMANCE DEMONSTRATION REPORT

J. W. MYERS
PPG INDUSTRIES, INC.
AIRCRAFT PRODUCTS
P.O. BOX 2200
HUNTSVILLE, AL 35804

March 12, 1992

Final Report for period June 1982 to September 1989

Approved for public release; distribution is unlimited

FLIGHT DYNAMICS DIRECTORATE
WRIGHT LABORATORY
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433-6553

NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely Government-related procurement, the United States Government incurs no responsibility or any obligation whatsoever. The fact that the government may have formulated or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication, or otherwise in any manner construed, as licensing the holder, or any other person or corporation; or as conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

This report is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

Tong C. Choe

TONG C. CHOE, 1LT
Project Engineer
T-38 Project

Duncan A. Dversdall PS

DUNCAN A. DVERSDALL, CAPT
Chief
Windshield Program Office

FOR THE COMMANDER

Richard E. Colclough Jr.

RICHARD E. COLCLOUGH JR.
Chief
Vehicle Subsystems Division

If your address has changed, if you wish to be removed from our mailing list, or if the addressee is no longer employed by your organization please notify WL/FIVR, WPAFB, OH 45433-6553 to help us maintain a current mailing list.

Copies of this report should not be returned unless return is required by security considerations, contractual obligation, or notice on a specific document.

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT Approve for public release; distribution is unlimited.
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) PPG-CDRL-5	5. MONITORING ORGANIZATION REPORT NUMBER(S) WL-TR-91-3112
6a. NAME OF PERFORMING ORGANIZATION PPG Industries, Inc. Aircraft Products Division 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Flight Dynamics Directorate Wright Laboratory (WL/FIVR)
6c. ADDRESS (City, State, and ZIP Code) P.O. Box 2200 Huntsville, Alabama 35804	7b. ADDRESS (City, State, and ZIP Code) WL/FIVR Wright Patterson AFB, Ohio 45433-6553
8a. NAME OF FUNDING / SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F33615-81-C-3403
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
64212F	1926	01	07

11. TITLE (Include Security Classification)
T-38 Forward Windshield
Development and Performance Demonstration Report

12. PERSONAL AUTHOR(S)
James W. Myers

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 6/82 TO 9/89	1992 March	297

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Windscreen Polycarbonate Distortion Bird Strike Transparent Panel Multiple Imaging Laminated Composite Reinforcement Aft Arch

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

According to Air Force information, approximately 500 bird strikes occur each year in Air Training Command (ATC) with over half of these on the T-38. The current windscreen provides some protection at the slower speeds flown during the final phases of the T-38 landing pattern. However, during climbs, cruise, and descents below 10,000-feet the T-38 is normally flown at speeds of 240-to-300 knots which presents a bird strike hazard by larger birds to the pilots.

The T-38 low level missions are of particular concern because they are flown at speeds of up to 420-knots. Based on training requirements, the altitude for T-38 low-level missions has decreased to 500-feet above ground level along with increasing the number of sorties required. Although the Air Force plans student load reductions, the relative number of high-speed, low-level navigation sorties will increase.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION	
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL Lt T.J. Choe	22b. TELEPHONE (Include Area Code) (513) 255-6524	22c. OFFICE SYMBOL WL/FIVR

Block 19

The bird impact testing of a T-38 laminated polycarbonate transparent panel with a composite aft arch reinforcement added to the production magnesium frame demonstrated the ability to withstand 400 knot, 4-pound bird impact. The transparent panel was made of polycarbonate, protected with PPG 5300 outboard liner. No problems were noted with PPG 5300 liner during the test period. Problems as a result of the PPG 8500 inboard coating were addressed with a change to PPG 9350 inboard coating. Additional work on the inboard coating identified as AS-4000/PPG 32AS resulted in better polycarbonate inboard ply protection and increased abrasion resistance.

Flight evaluations of the original design at seven ATC Bases resulted in test parts being removed for safety reasons after the test time frame was completed. Reasons were reduction of overall pilot visibility caused by reverse curvature along edges which caused distortion and multiple imaging. Reverse curvature was required for fit to the frame. The composite aft arch reinforcement that was added to the magnesium frame increased arch size thickness, to a point where it violated both sutdent and insturctor pilot vision area. Another problem was the variation in size of existing magnesium frames where each individual transparent panel had to be fit to a speciifc frame and drilled to fit only that frame.

Although magnesium frames are light-weight and statically strong, they are of very little use in dynamic bird impact. Design of a total composite frame has been pursued by the Air Force which will result in increased aft arch and sill vision area. Design of this frame will eliminate reverse curvature that was the cause of distortion and multiple imaging, along with simplicity of transparent design, reducing the cost of fabrication, and is conclusive to obtaining good optical quality.

PREFACE

Preparation of this Final Report was by PPG Industries, Inc., Aircraft Products, Huntsville, Alabama, under Air Force Contract F33615-81-C-3403, Project 1926-0107, "Alternative Transparencies For Improved Birdstrike Protection," Task 1, T-38 Forward (Student) Windshield. This work was sponsored by the Air Force Wright Laboratory, Flight Dynamics Directorate, Wright-Patterson Air Force Base, Ohio. Air Force Administrative and Technical Support was under the direction of Mr. William R. Pinnell and Lt T.J. Choe, WL/FIVR, Air Force Project Engineer. Active support of Mr. William R. Pinnell and Lt T.J. Choe on this project is gratefully acknowledged for their comments, insights, and technical direction.

The work described took place from November 1984, through September 1989. PPG Industries, T-38 Program coordination was provided by Mr. Sherman Stewart and Mr. James Myers.

FOREWORD

According to Air Force information, approximately 500 bird strikes occur each year in Air Training Command (ATC) with over half of these on the T-38. The current windscreen provides some protection at the slower speeds flown during the final phases of the T-38 landing pattern. However, during climbs, cruise, and descents below 10,000-feet the T-38 is normally flown at speeds of 240-to-300-knots which presents a bird strike hazard by larger birds to the pilots.

The T-38 low level missions are of particular concern because they are flown at speeds of up to 420-knots. Based on training requirements, the altitude for T-38 low-level missions has decreased to 500-feet above ground level along with increasing the number of sorties required. Although the Air Force plans student load reductions, the relative number of high-speed, low-level navigation sorties will increase.

The bird impact testing of a T-38 laminated polycarbonate transparent panel with a composite aft arch reinforcement added to the production magnesium frame demonstrated the ability to withstand 400-knot, 4-pound bird impact. The transparent panel was made of polycarbonate, protected with PPG 5300 outboard liner. No problems were noted with PPG 5300 liner during the test period. Problems as a result of the PPG 8500 inboard coating were addressed with a change to PPG 9350 inboard coating. Additional work on the inboard coating identified as AS-4000/PPG 32AS resulted in better polycarbonate inboard ply protection and increased abrasion resistance.

Flight evaluations of the original design at seven ATC Bases resulted in test parts being removed for safety reasons after the test time frame was completed. Reasons were reduction of overall pilot visibility caused by reverse curvature along edges which caused distortion and multiple imaging. Reverse curvature was

required for fit to the frame. The composite aft arch reinforcement that was added to the magnesium frame increased arch size thickness, to a point where it violated both student and instructor pilot vision area. Another problem was the variation in size of existing magnesium frames where each individual transparent panel had to be fit to a specific frame and drilled to fit only that frame.

Although magnesium frames are light-weight and statically strong, they are of very little use in dynamic bird impact. Design of a total composite frame has been pursued by the Air Force which will result in increased aft arch and sill vision area. Design of this frame will eliminate reverse curvature that was the cause of distortion and multiple imaging, along with simplicity of transparent design, reducing the cost of fabrication, and is conclusive to obtaining good optical quality.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF TABLES

1.0 PROTOTYPE BIRD IMPACT TESTING

This testing followed extensive preprototype testing stage where a single cross section was established for the prototype portion of the program. This cross section is depicted in Figure 1. Aft Arch Reinforcement of the magnesium frame was Kevlar®/Fiberglass hybrid composite bonded directly to the frame. The windshield consists of an outboard ply of 0.375-inch aircraft grade polycarbonate with an outboard liner of nominally 0.030-inch-thick PPG 5300 liner. This polycarbonate ply was laminated to an inboard ply of 0.187-inch aircraft grade polycarbonate with an inboard coating of 0.003-0.005-inch-thick PPG 8500 coating. The inner layer in this laminate is 0.060-inch-thick PPG 112 material. Located at the Aft Arch of windshield is a 0.160-inch-thick Hexcel Fiberglass outboard retainer and a 0.035-inch-thick stainless steel inboard retainer are bonded to the laminate with Uralane 5738. To complete the assembly a wedge of Gilfab Fiberglass is bonded to the inboard Aft Arch with Uralane 5738. This wedge serves to match windshield and frame contour. The fabricated nose and sill fairings were from 6061-T6 Aluminum, 0.100-inch-thick. The windshield is bolted to the frame with #10 NAS aircraft bolts at the sills and NAS 1/4-inch aircraft bolts in the aft arch. Urethane UR-2102 was used to seal outside windshield to aft arch and edge fairings. This material provides a smooth transition from the windshield surface to the fairing, besides providing a weather seal.

All Prototype Bird Impact Testing used the rigid blue support frame constructed by PPG for mounting and securing windshield frame (Figures 2 and 3, Test Plan - Bird Impact). This support system simplified easy access to the transparency mounting system, greater flexibility of camera locations, and faster change out from one target to the next. Because of the knowledge gained in preprototype testing, PPG recognized that

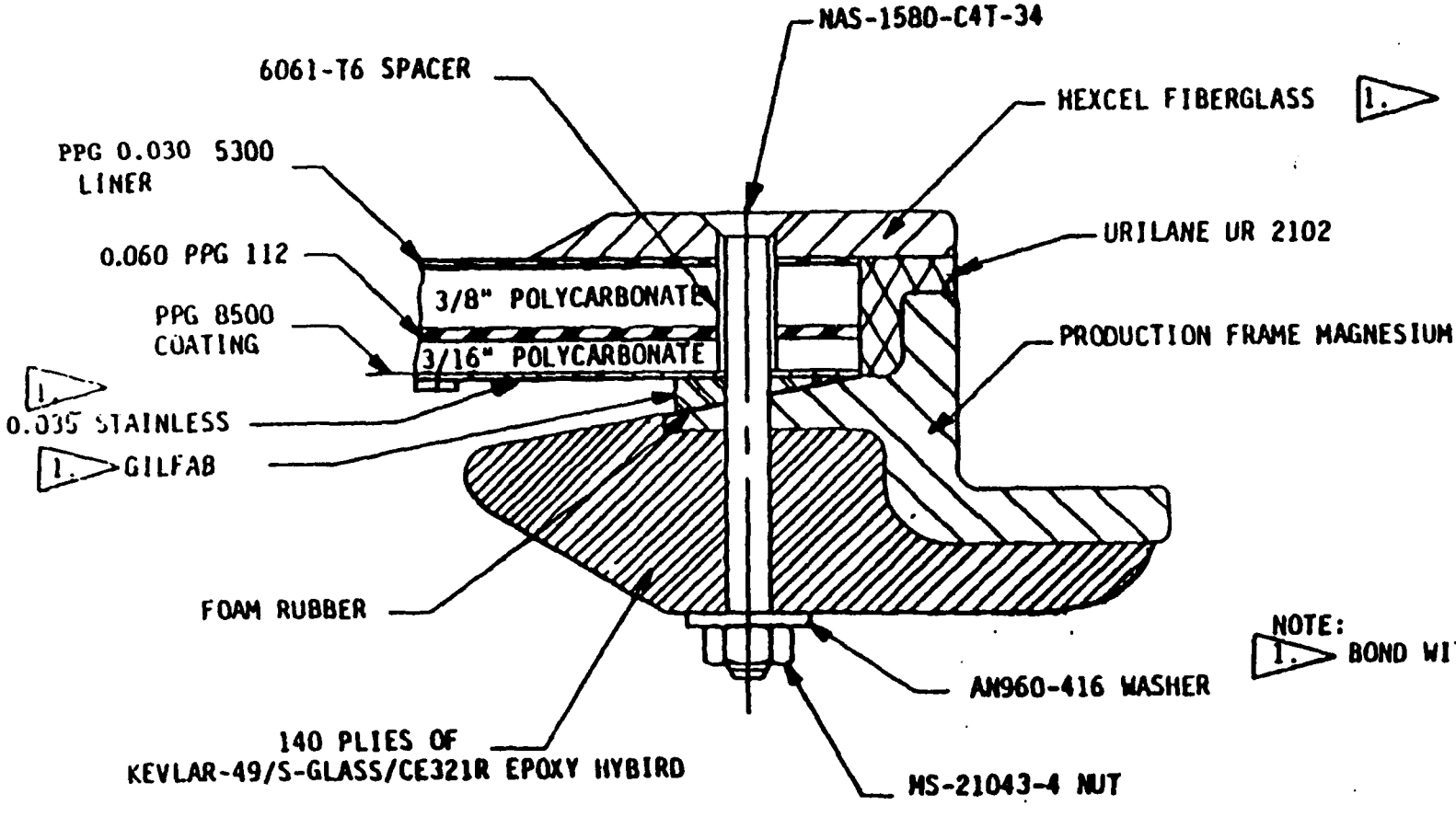


Figure 1. Prototype Centerline Cross Section

Figure 1

2

Figure 2

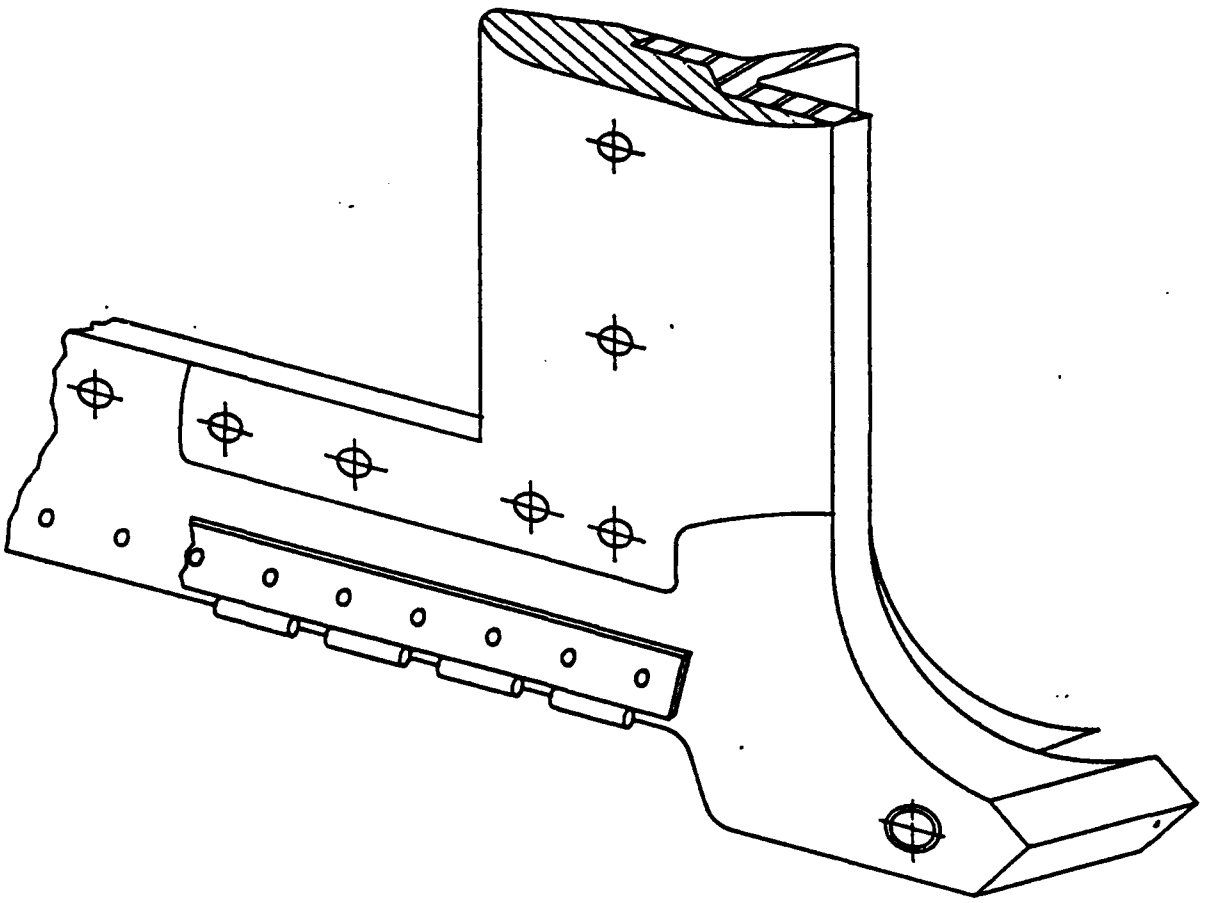


Figure 2. T-38 Composite
Reinforced Forward
Windshield Frame

Figure 3

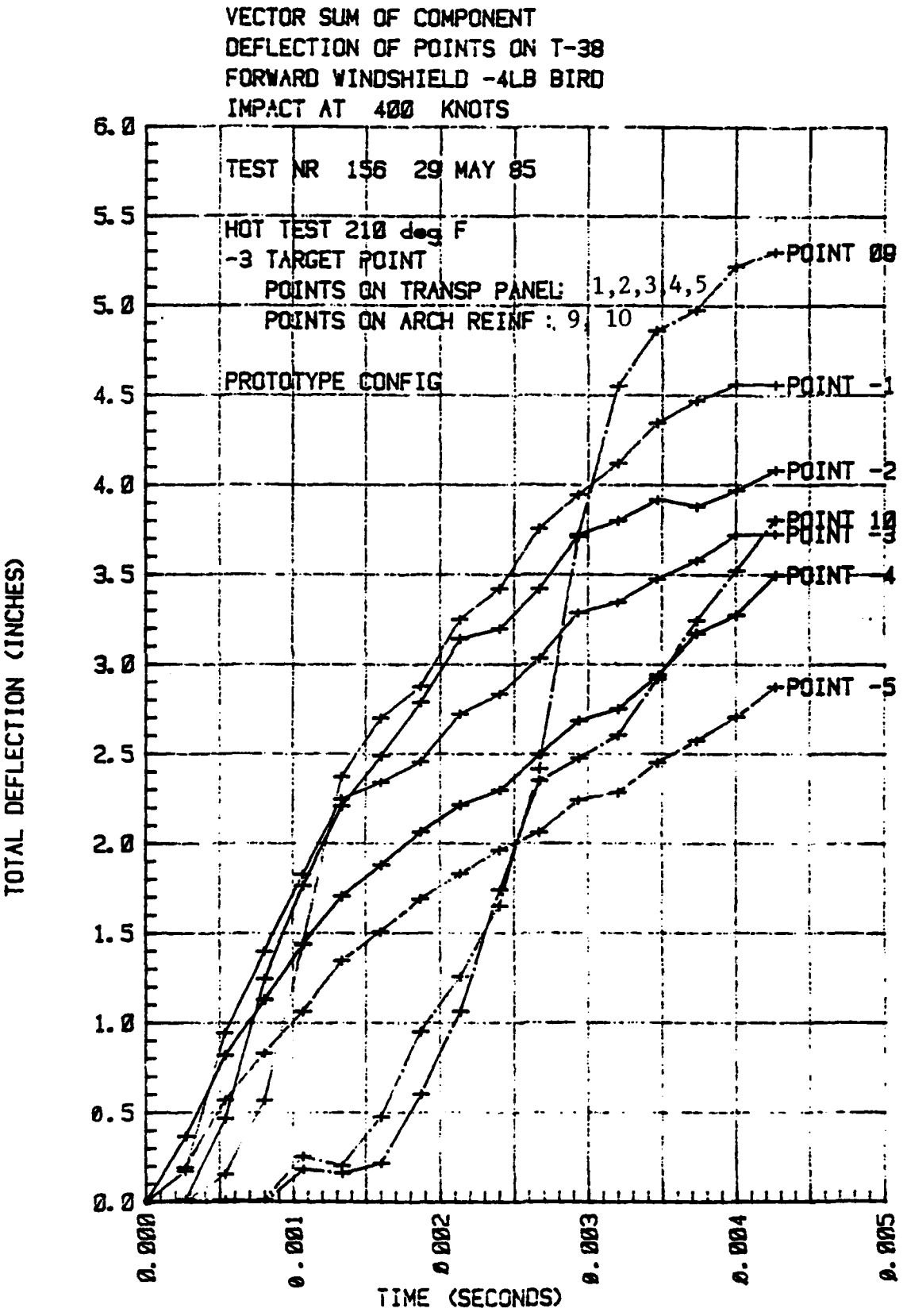


Figure 3. Triangulation Plot
Points 1 Thru 5, 9, 10,
Shot #156

possibly more than one of the impact locations could be tested on any single windshield. This contract deviation was an agreement by PPG and WPAFB personnel. All prototype impact testing was at PPG Flight Impact Facility in Huntsville, Alabama.

1.1 Bird Impact Testing - May 1985

This series of designed testing was to impact two test windshields using Table 1 of the Test Plan - Bird Impact for temperatures, locations and speeds. The first five shots of the Table are included in this testing. Hot temperatures were generated by a thermal heating blanket system, while cold temperatures would be reached using gaseous liquid nitrogen as a cooling mechanism. The specified impact locations are on Figure 4 of the Test Plan - Bird Impact.

1.2 Prototype Bird Impact Test Results - May 1985

Five bird impacts on two windshields were made during this phase of the test program. The first test window, number 322-52, was impacted at 401.62-knots with a 4.012-pound bird. The impact shots on the first test window are numbers 156, 157, 158 and 159.

1.2.1 Shot #156

Shot #156 was 9-inches forward of aft arch on windshield center line, after a 15-minute soak period at an outboard surface temperature of approximately 210°F. Removing the electric heating blanket before impact caused the actual surface temperature reading at impact to drop to 183.7°F outboard and 162.6°F inboard. The impact produced sufficient deflection in the aft arch to allow a small amount of bird debris to enter the cockpit area and strike the witness plate.

Table 1. T-38 Frame Measurements

												STATUS CODE:			100-- FRAME BEFORE REINFORCEMENT									
FRAME ID SUFFIX CODE:		W-- PREVIOUSLY BROKEN AND WELDED													200-- WITH REIFORCEMENT NO PANEL									
		H-- SOME FRAME DIMENSION HELD WHILE MEASURING OTHERS													300-- WITH REINFORCEMENT WITH PANEL									
FRAME # NONE	STATUS	WEIGHT	TEST #	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
SCALED FROM DWG				31.50	33.86	33.86	36.47	19.12	28.28	28.88	29.45	29.86	29.82	29.76	29.84	18.89	18.64	17.89	16.58	14.99	18.89	18.64	17.89	16.58	14.99
				A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
FRAME # 1368W	300		224	30.80	33.85	33.88	N/A	19.33	28.46	28.89	29.29	29.52	29.69	29.83	29.53	19.25	18.90	17.95	16.40	14.70	19.00	18.53	17.75	16.18	14.66
FRAME # 1368W	200	26	POST TEST DISMANTLED WEIGHT																						
FRAME # 1368W	300A			30.04	COMPRESS A			19.58																	
				30.29	COMPRESS A			19.46																	
				30.54	COMPRESS A			19.46																	
				30.79	RELAXED			19.42																	
				31.04	SPREAD A			19.20																	
				31.29	SPREAD A			19.18																	
				31.49	SPREAD A			19.08																	
				31.83	SPREAD A			18.98																	
				A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
FRAME # 1533	100			31.56	33.78	33.75	36.27	19.13	28.38	28.94	29.38	29.63	29.88	30.00	29.97	19.00	18.63	17.88	16.09	14.94	19.00	18.63	17.81	16.50	15.00
				A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
FRAME # 1570W	100			32.25	33.75	33.75	36.46	18.88	28.50	29.00	29.50	30.00	30.31	30.56	30.75	18.93	18.88	18.31	16.94	15.31	18.88	18.63	17.94	16.56	15.13
FRAME # 1570W	200	26.5		32.08	33.75	33.78	36.56	19.32	28.41	28.94	29.38	29.81	30.13	30.38	30.56	19.15	18.80	17.97	16.40	14.98	19.15	18.68	17.90	16.35	15.04
FRAME # 1570W	300		226	31.80	33.75	33.78	36.56	19.40	28.32	28.77	29.21	29.62	29.89	30.34	30.38	19.20	18.85	17.81	16.50	14.95	19.20	18.70	17.85	16.35	14.95
				A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
FRAME # 1570W	300		226	31.50	COMPRESS A			19.52																	
	300			31.60	COMPRESS A			19.50																	
	300			31.70	COMPRESS A			19.48																	
	300			31.80	RELAXED			19.46																	
	300			31.90	SPREAD A			19.40																	
	300			32.02	SPREAD A			19.36																	
	300			32.12	SPREAD A			19.32																	
	300			32.25	SPREAD A			19.27																	
				A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
FRAME # 1576	100			31.80			36.31	19.19	28.28	28.88	29.28	29.63	29.84	30.09	30.11	19.09	18.72	17.88	16.56	15.00	19.00	18.63	17.63	16.31	14.94
FRAME # 1576	200			31.80	33.80	33.70	36.44	19.09	28.31	28.94	29.38	29.75	30.05	30.38	30.37	18.95	18.63	17.86	16.59	15.05	18.93	18.53	17.75	16.42	15.08
FRAME # 1576H	200	HELD DIMEN A		31.50			36.46	19.18	28.28	28.90	29.31	29.62	29.85	30.13	30.02	19.03	18.70	17.87	16.50	14.90	19.03	18.60	17.80	16.38	14.96
FRAME # 1576W	300		222	31.93			36.63	19.38	28.44	28.94	29.38	29.75	30.06	30.31	30.50	19.20	18.80	17.98	16.80	15.35	19.20	18.75	18.00	16.66	15.20
				A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
FRAME # 1601W	300		221	MOUNTED ON FUSELAGE				19.31							30.13	19.18	18.90	17.06	16.80	15.06	19.10	18.70	17.60	16.06	14.75
FRAME # 1601W	200	28.5	POST TEST DISMANTLED WEIGHT																						
FRAME #1306	300	75	NASA AIRCRAFT																						
FRAME # 1532	300	75	KELLY AIRCRAFT																						
ACRYLIC W/S		59	CURRENTLY FLYING CONFIGURATION																						
ACRYLIC W/S		61	CURRENTLY FLYING CONFIGURATION																						

Table 1. T-38 Frame Measurements

Figure 4

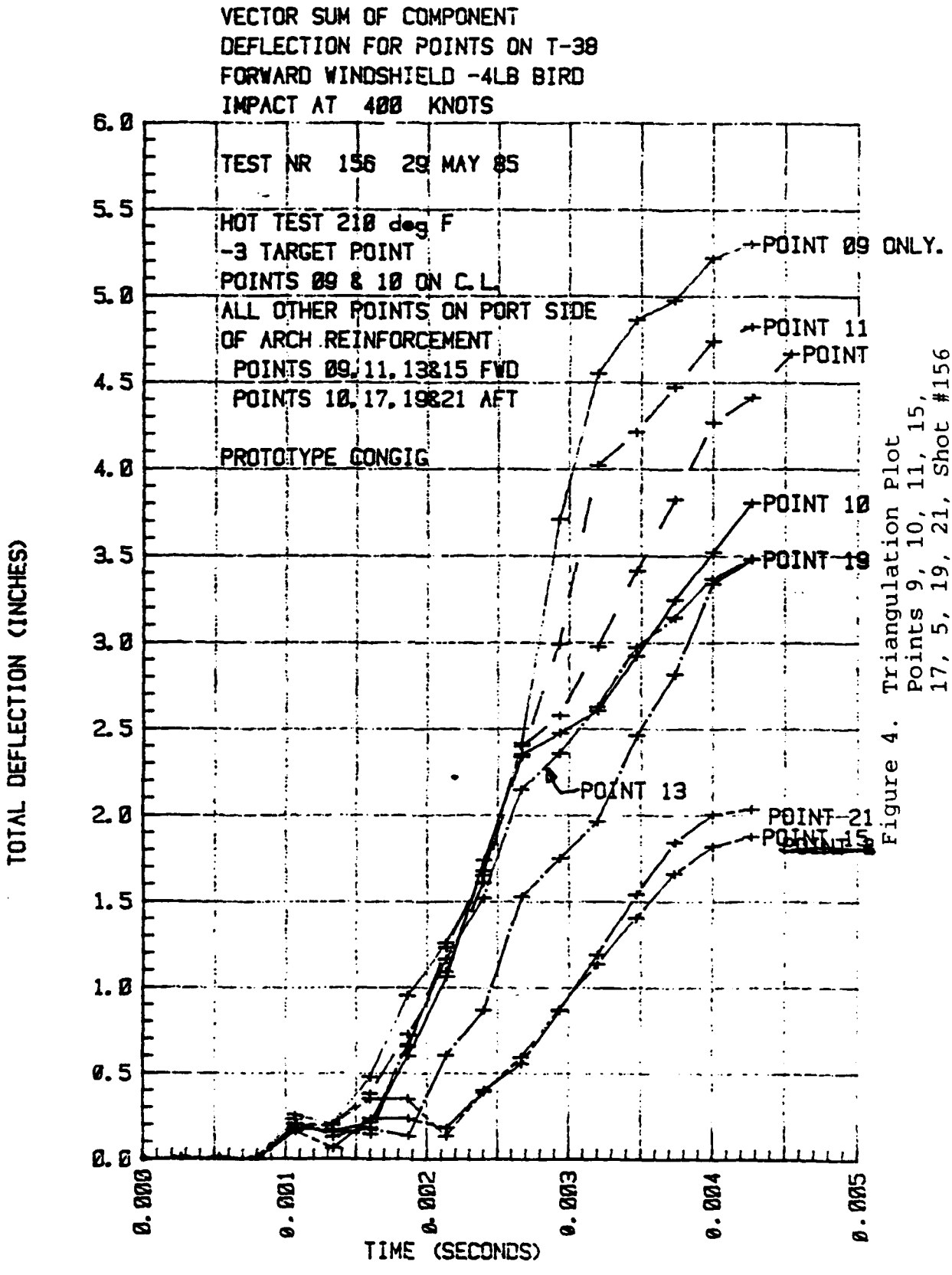


Figure 4. Triangulation Plot
Points 9, 10, 11, 15,
17, 5, 19, 21, Shot #156

Eight thermocouples were positioned on the windshield for temperature gradient verification. Two of the three required readings were taken 12-inches from the nose, on the center line and at a position 3-inches up from the sill, one inboard and the other outboard. The third reading was taken inboard center line at a position 10-inches away from the windshield surface. All other thermocouples are positioned as shown on the sketch in data section of the Bird Impact May 29, through May 31, 1985, report (Appendix A). The data presented has information headings that do not represent actual locations displayed on sketch.

1.2.2 Shot #157

Shot #157 was on the same windshield and in the same location but at room temperature. The impact was at 137.2-knots with a bird package weight of 3.996-pounds. A small amount of debris entered the cockpit area on this shot.

The third and fourth shots were at room temperature on windshield 322-52 but in the sill corner location as specified in Figure 4 of the Test Plan - Bird Impact.

1.2.3 Shot #158

Shot #158 was a 404.6-knot shot with a 4.018-pound bird that did no apparent additional windshield system damage.

1.2.4 Shot #159

Shot #159 was a 136.98-knot shot with a 4.016-pound bird that did no apparent additional windshield system damage.

Installation of windshield number 322-45 was the next sequence of test shots which consisted of cold and room temperature shots.

1.2.5 Shot #160

Shot #160 was after a cooling soak for 15-minutes at approximately -10°F outboard surface temperature. The same eight thermocouple locations recorded previously were used for the hot shot. Just before impact, removal of the enclosure used to contain the cooling gases and several photographic lamps were turned on. The lamps generated enough heat that actual test temperatures at impact were +5°F on the outboard surface and +40°F on inboard surface. Impact was at 402.35-knots with a 4.002-pound bird and proved to be a catastrophic type failure. A large plug type section of the windshield was blown out in the impact area. This location was a point 9-inches forward of aft arch on transparency center line.

During the above testing it was determined that the horizontal leg, bottom composite reinforcement was not required as shown in Figure 2 Test Plan - Bird Impact. UDRI had the tooling revised to accommodate removal of horizontal leg which helped reduce complexity of composite lay up.

All test parts were prepared and measured for triangulation analysis for deflection. Triangulation analysis was by W. R. Pinnell for test #156 only. Triangulation data is shown in Figures 3 and 4. Reference Appendix A, Bird Impact Test Report, T-38 Alternative Transparencies, May 29 through May 31, 1985, informal report for all data including pre- and post-test photographs.

1.3 Bird Impact Testing - August 1985

This series of testing used the test evaluations of previously conducted shots and data generated by immediately preceding test shot results. All impacts were done with 4-pound birds at velocities determined by program director, Sherman Stewart and coordinated with USAF personnel. This approach was chosen to allow a definition of transparency penetration velocity at specific test temperatures. Test temperatures were to be either ambient room temperature or cold (+25^{0}F).

1.4 Prototype Bird Impact Test Results - August 1985

Six bird impacts were made on four test windshields during the completion of this test program portion. Two windows were impacted twice, with the remaining two tested only once.

1.4.1 Shot #184

Shot #184 was 393.1-knots on windshield number 322-54, with a 4.002-pound bird at room temperature of 70^{0}F. The window passed with no major damage, other than an approximate permanent deflection of 0.25-inch in the aft arch. Several pieces were removed from the arch material by the impact. The test also permitted a few pieces of bird residue to hit the witness plate.

1.4.2 Shot #185

Shot #185 was on windshield number 322-72 with a 4.012-pound bird at 400.9-knots, test was a failure. Impact was after cold soaking the panel at +25^{0}F for 15-minutes. A flap of some 12-inches by 8-inches opened in the impact area and allowed bird debris to enter cockpit.

1.4.3 Shot #186

Shot #186 was on windshield number 322-57 after a cold soak at +25^{0}F for 15-minutes. Speed was 393.2-knots with a 4.014-pound bird and was a failure. Again an approximate 12-inch by 8-inch flap opened allowing some bird debris to enter cockpit area. Several cracks generated from flap area toward forward arch. These first three shots were at a location 9-inches forward of aft arch on windshield center line. Removal of stainless steel inboard buffer before test shot #186 may have caused some inboard polycarbonate ply damage.

1.4.4 Shot #187

Shot #187 was on windshield number 322-54, previously impacted on shot #184. Impact location point on this test was 6-inches aft of the forward sill on windshield center line. Shot was at room temperature with a 4.016-pound bird, a velocity of 396.2-knots, and the windshield passed. Previous shot damage cracks propagated across windshield center.

1.4.5 Shot #188

Shot #188 was at room temperature, center of windshield center line. Windshield number 322-52 used for this test was tested before on shot numbers 156, 157, 158, and 159. A 4.002-pound bird impacted the windshield at 392.5-knots without damaging windshield. There was no penetration nor visible damage from the test.

1.4.6 Shot #189

Once more, shot #189 used windshield number 322-52. Impact location was changed to the same position as used in the first three shots, 9-inches forward of the aft arch on windshield windshield center line. This test was after a 15-minute cold soak at +25^{0}F. The impact was at 302.1-knots with a 3.998-pound bird and produced no window damage. Transparency inboard stainless steel buffer was removed before testing.

Again all test parts were prepared and measured for triangulation analysis for deflection. Triangulation analysis was by W.R. Pinnell for test #184 only. Triangulation data is shown on Figure 5. Shot #189 established the first cold capability (+25^{0}F) at 300-knots. Reference Appendix B, Bird Impact Test Report, T-38 Alternative Transparencies, August 9, 1985, through August 15, 1985, for all data including pre- and post-test photographs.

1.5 Prototype Bird Impact Test Results - October 1985

This series of testing consisted of two-bird impacts on separate windshields. They were mounted to the original test support structure used in all bird impact tests before this series of tests.

1.5.1 Shot #213

Shot #213 was at 352.8-knots with a 4.012-pound bird on windshield number 322-76 and was successful. The shot was at a nominal +26^{0}F on the outboard surface, after a 15-minute soak period at +25^{0}F. This soak period produced a temperature of 53^{0}F on the inboard surface just before impact.

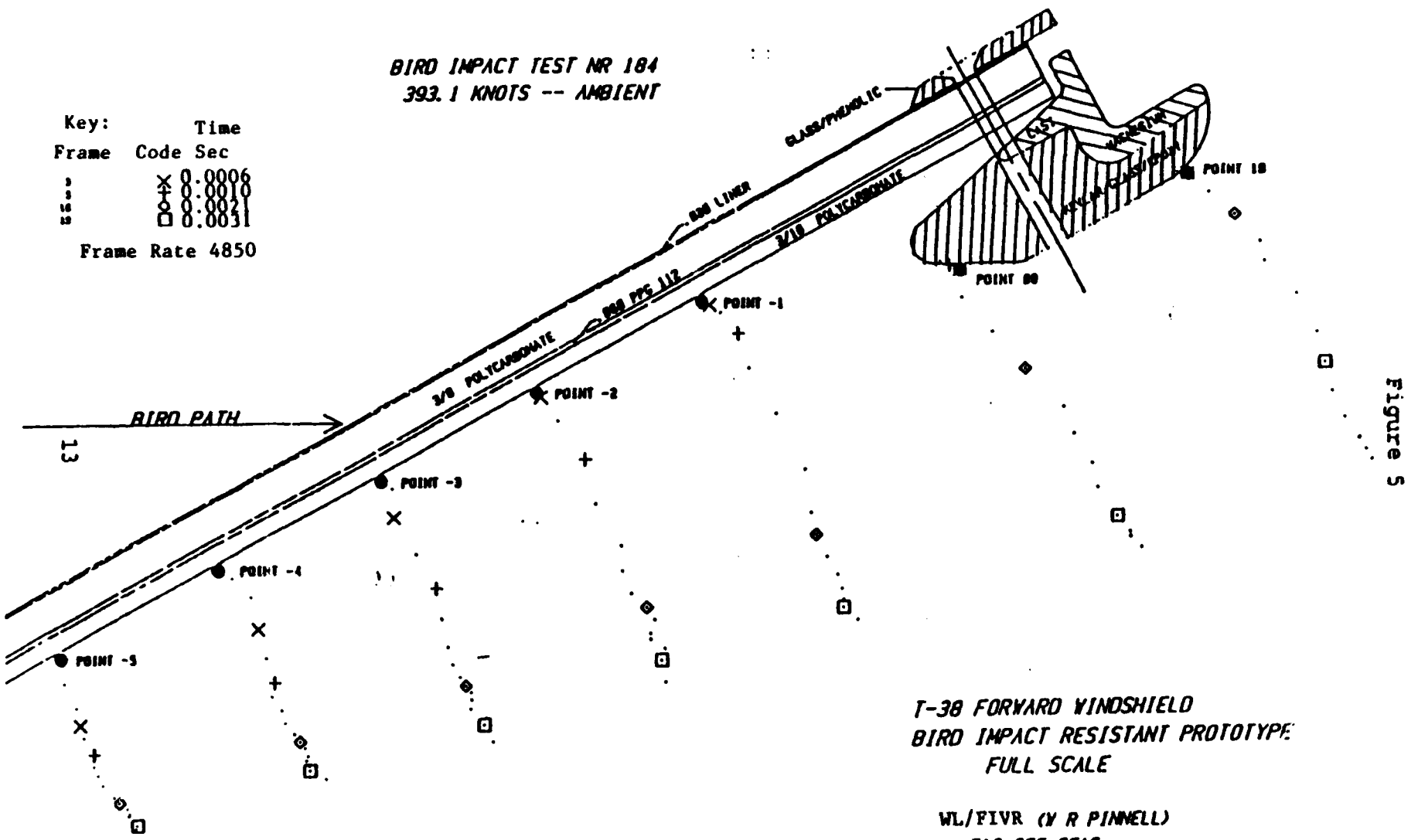


Figure 5

Figure 5. Triangulation Data Cross Section Plot Shot #184

1.5.2 Shot #214

Shot #214 was at 345.8-knots with a 4.016-pound bird. This test proved to be a failure when a small plug was blown out of the impact area. Temperatures just before impact were -1^{0}F on the outboard surface and +40^{0}F on the inboard surface. The temperatures were established by soaking windshield for 15-minutes at 0^{0}F.

These two tests established the speed (350-knots) and cold temperature (+25^{0}F) capability. Reference Appendix C, Bird Impact Test Report, T-38 Alternative Transparencies, October 1, 1985, through October 2, 1985, and November 14, 1985, through November 22, 1985, for all data including pre- and post-test photographs.

2.0 FLIGHT QUALITY QUALIFICATION BIRD IMPACT TESTING

Flight quality testing was on the final design configuration determined during prototype testing (Figure 6). Flight quality windshields were then representative of production parts. Flight quality testing was the final design and manufacturing certification process.

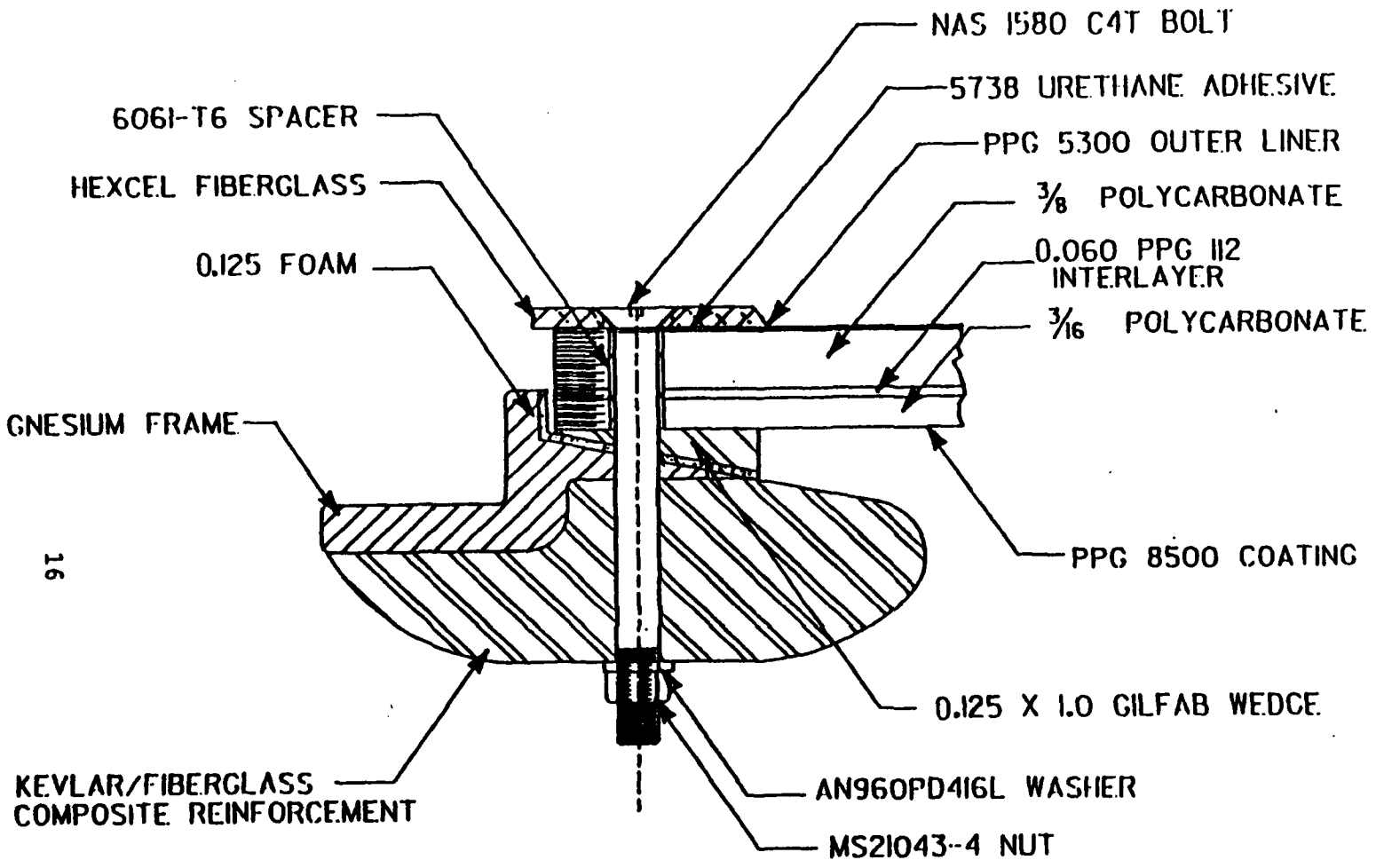
All flight quality bird impact testing was in an actual T-38 fuselage supplied to PPG by WPAFB. All transparencies were in their respective positions on the fuselage during flight quality impact testing. Upon satisfactory completion of the flight quality testing the windshield system was then ready for Developmental/Operational Test and Evaluation (D/OT&E) installation.

Because of the extensive preprototype and prototype bird impact testing, the aft arch centerline impact location was determined to be the worst case test condition and chosen as the impact location for various temperature requirement tests. This location was also chosen for the secondary impact location at 130-knots. All testing was documented, using three high-speed color film cameras (approximately 5,000 frames-per-second).

2.1 Flight Quality Bird Impact Results - November 1985

2.1.1 Shot #221

Shot #221 was on windshield number 322-80 at the aft arch centerline location. The conducted impact was at room temperature with a 4.008-pound bird, at a velocity of 393.6-knots. The impact was determined to be successful. Some minor bird debris penetrated into the cockpit, but the debris entered over the aft arch as it deflected during impact.



FLIGHT QUALITY BIRD IMPACT
AFT ARCH ℄ CROSS SECTION

Figure 6. Flight Quality Bird Impact Aft Arch & Cross Section

Figure 6

2.1.2 Shot #222

Shot #222 was a second aft arch centerline location shot on windshield number 322-79 with an outboard surface temperature of 208°F and inboard surface temperature of 159°F. These established temperature values were completed before impact after a 15-minute soak at 210°F. Impact was at 401.5-knots with a 4.008-pound bird. The windshield passed the impact with only a few small outboard ply cracks. Aft arch deflection again allowed some bird debris to enter the aircraft.

2.1.3 Shot #223

Shot #223 was on windshield number 322-79, but at an ambient room temperature condition of 75°F. The test was at 132.7-knots with a 4.012-pound bird in the same location as shot #222. Once again the windshield passed the test without any additional panel damage.

2.1.4 Shot #224

Shot #224 was an aft arch centerline conducted at low temperature on windshield number 342-10, at a velocity of 351.9-knots, with a 4.010-pound bird test results were good. Temperatures were +26°F on the outboard surface and an inboard surface temperature of +39°F. These values were reached after a 15-minute soak at 25°F. Post-test evaluation revealed several large cracks in the polycarbonate plies of the window. Aft arch deflection allowed a minimal amount of bird debris to enter cockpit area.

2.1.5 Shot #226

Shot #226 was at room temperature on windshield number 342-09. Impact occurred at a velocity of 398.9-knots, with a 4.020-pound bird and proved to be a success. The nose impact produced a crack in the 3/8-inch polycarbonate ply that radiated from impact position up to aft arch.

2.1.6 Shot #227

Shot #227 was a second impact on windshield number 342-09. Impact location changed from the nose position to centerline of the unit at transparency midpoint. Impact was at room temperature of 64^{0}F, with a 4.020-pound bird traveling at a velocity of 400.8-knots and was a successful test.

2.1.7 Shot #228

Shot #228 was the third impact shot on windshield number 342-09. Impact was port sill location as defined in the original testing document. Impact was at 400.2-knots with a 4.008-pound bird and again proved to be a success. The room temperature was 58^{0}F at impact.

All flight quality impact tests met the 4-pound, 400-knot requirement for ambient and hot temperature shots (210^{0}F) and the 4-pound, 350-knot requirement for cold temperature requirement (+25^{0}F).

All test parts were prepared and measured for deflection using triangulation analysis. Although no analysis was done, all testing was evaluated as meeting the requirements. Reference Appendix C, Bird Impact Test Report, T-38

Alternative Transparencies October 1, 1985, through October 2, 1985, and November 14, 1985, though November 22, 1985, for copies of temperature data on hot and cold impact shots, also for pre- and post-test photographs.

3.0 NASA SPECIAL WINDSHIELD

In January 1985, NASA Langley Research Center requested a bird impact resistant T-38 transparency for their aircraft. They expressed a desired April/May delivery, with a projection of flying special low-level test missions during June/July. This installed transparency was in a magnesium frame already reinforced with a composite aft arch reinforcement, supplied by the University of Dayton Research Institute (UDRI), under subcontract to PPG Industries. The transparency cross section is depicted in Figure 1 and shows the cross section that evolved from preprototype testing and would be used in all prototype testing. A transparency was manufactured to fulfill this requirement and optically inspected by PPG personnel and NASA Research Pilot, Phil Brown. PPG declared that the transparency did not meet optical specifications as stated in statement of work, but NASA (Phil Brown) said it was acceptable for special mission flying. The transparency was installed in the frame and shipped to NASA Langley Research Center on May 16, 1985. Specialized cleaning instructions and recommended solutions were delivered with the transparency system.

NASA aircraft transparency installation began the week of June 19, 1985, with PPG personnel Mr. James Myers and Mr. Tom Rukavina assisting Kentron Service personnel Mr. Bruce Foster, Crew Chief, and Mr. Sam Talley with installation. After rough fitting the frame fairings to aircraft, PPG personnel departed from NASA Langley. Kentron personnel continued the difficult task of mating and shimming piano hinges on the frame to existing piano hinge on aircraft. Just before final installation of transparency system to aircraft, a scratch was discovered on the inboard coating, in an area approximately 1-inch long on the port sill area. On June 30,1985, the installed windshield was then inspected by PPG personnel Mr. Sherman Stewart (Senior Design Engineer) and

Mr. James Myers (Project Engineer) at Huntsville, Alabama, Jetplex. The scratch was only in the inboard 8500 protective coating and did not penetrate the polycarbonate. A thin film of RTV 732 silicone was applied to protect the exposed polycarbonate in the bottom of the scratched area. This was a simple patch to fill the void, not a repair. The transparency system was returned and installation completed on the aircraft. Pressurization testing was completed July 9, 1985, and first flight occurred July 12, 1985. Special testing occurred July 24, through July 26, 1985, with no transparent system problems. Although this transparency did not meet optical specifications, NASA felt it suitable to continue flying, providing pilots with increased birdstrike protection.

On September 9, 1985, NASA reported an impact with a large hard shell bug that left a mark in the PPG 5300 liner. Some of the remains and skid type mark was left on the surface of the PPG 5300 liner in the right central area of the transparency. After thorough cleaning to remove remains, the skid mark was still visible, but after exposure to sunlight and several flights the mark had disappeared. The reason for this disappearance is "memory or self-healing characteristics of the PPG 5300 liner." The self-healing characteristic is enhanced by warm sunshine, heat from a common hair dryer, or heat gun. Throughout the continued use of this unit no discoloration, delamination, peeling, crazing, loss of light transmission, or haze increase as accured.

Forward windshield certification for Operational Test and Evaluation (OT&E) was by NASA Langley T-38 flying experience, tail #511. Accumulated during August 1985, were almost 5 flying hours, some of which included very high-speed (570-knots) runs at an altitude of 12,000-feet. On December 13, 1985, aerobatic maneuvers including loops, cuban eights, and emelmans, subjecting the aircraft to 5 "G" loading conditions

six times and 500-knot airspeed at an altitude of 5,000-feet. A flight performance demonstration was conducted on December 18, 1985, and consisted of the following:

> A 60-degree dive/high-speed mission, following a 15-minute low-temperature soak of -58^{0}F at an altitude of 41,000-feet. The aircraft was subjected to a maximum speed of Mach 1.3, at an altitude of 30,000-feet. This followed a leveling off and deceleration at an altitude of 17,000-feet (600-knots decelerating to 500-knots). Estimated time of windshield exposure to super sonic conditions during this mission is 30-seconds. Following these missions, cross-country flying time resulted in a total accumulation of approximately 70 flight hours from July 1985, through early January 1986, supporting the Air Force D/OT&E. In October 1986, the transparent panel outboard port sill was severely abraded by what appeared to be a belt buckle. After cleaning and outdoor sun exposure, the marks disappeared.

NASA continued flying the original transparent panel until October 1988. PPG Industries replaced the unit, due to inboard PPG 8500 protective coating failure. During the time original transparent panel was in service, nearly 400 flight hours of service accumulated with no major problems.

4.0 DEVELOPMENTAL/OPERATIONAL TEST AND EVALUATION (D/OT&E)

During September 1985, installation of the D/OT&E unit started at San Antonio Air Logistics Center (SA-ALC). A student windshield frame was received from Northrop Corporation and fitted with the bird impact resistant windshield. This frame had been rejected because the bolt hole pattern was out of specification. Since transparent panel installation was to the individual frame and the edge of part-to-hole specification was not violated, this frame was usable. After frame was faired to the ALC aircraft and piano hinges shimmed and attached, canopy would not close at aft arch and forward canopy interface. Forward windshield assembly interference fit problems to airframe and canopy encountered during proof fitting were related to manufacturing tolerances of forward windshield frame, matching of frame, and fuselage dimensions. The solution for this problem was to install frame reinforcement and bird impact resistant transparent panels in frames removed from specific D/OT&E aircraft and reinstallation of these assemblies on the aircraft from which removed. A WL/FIVR and PPG study involving detailed geometric measurement of frame geometry before and after composite reinforcement and transparent panel installation, suggested that the bird impact frame modifications will not prelude reinstallation of modified frames on aircraft from which removed (see Table 1 and Figures 7, 8, and 9). The relationship was determined between aft arch height and span dimension at aft sill fasteners. In the event pre-installation nondestructive testing revealed damage to a frame which would preclude continued flight worthiness, measurements of the air frame could be used to determine if the geometry of one of the small number of flight quality frames at WL would be compatible with the subject aircraft. If compatibility was evident, then the WL frame would be made available.

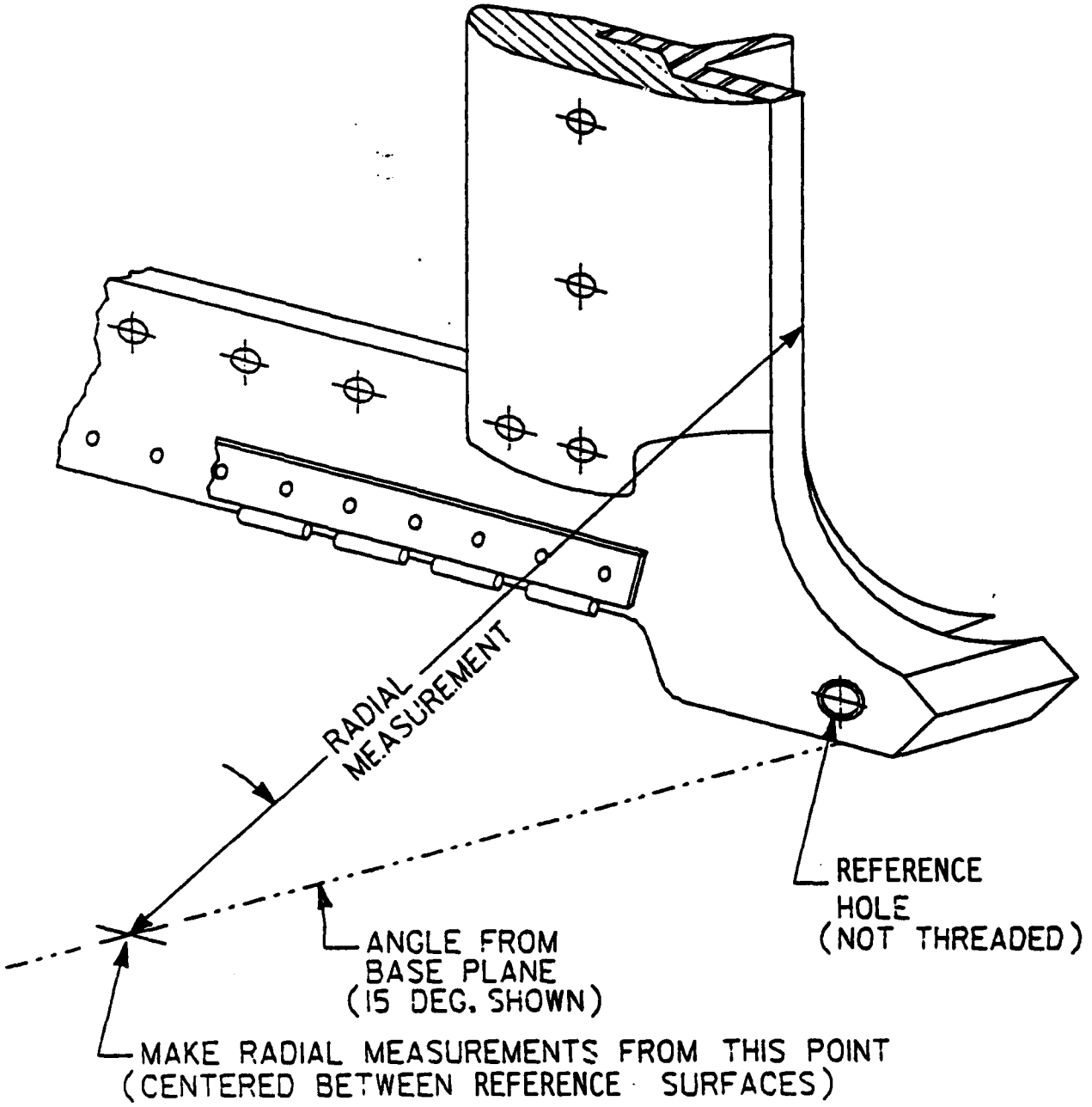
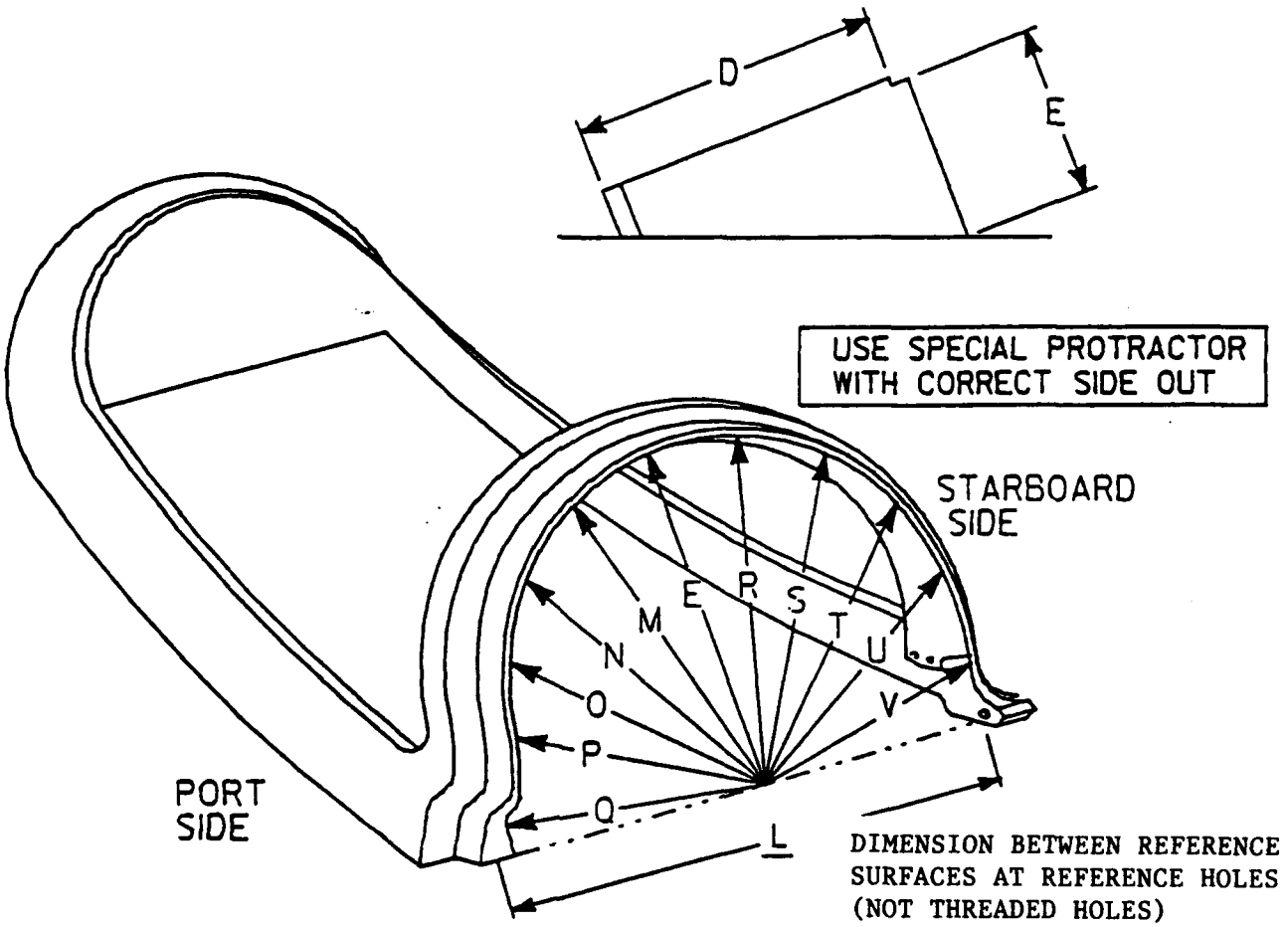


Figure 7. T-38 Forward Windshield Frame Aft Corner View



ANGLE FROM BASE PLANE (DEGREES)	RADIAL PORT SIDE (INCHES)	MEASUREMENT STARBOARD SIDE (INCHES)
15	Q	V
30	P	U
45	O	T
60	N	S
75	M	R
90	E	E

Figure 8. T-38 Forward Windshield Frame Radial Measurements

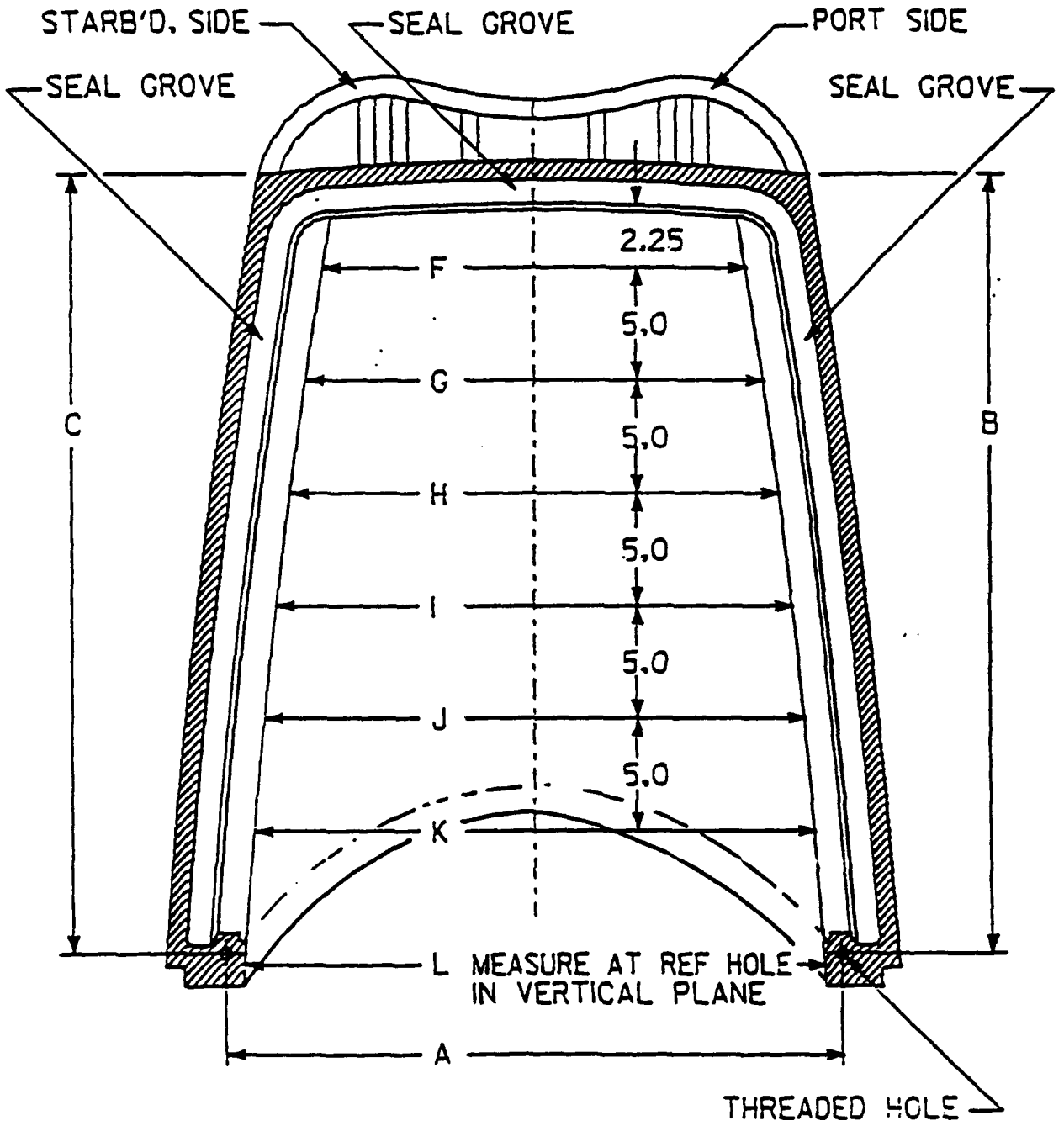


Figure 9. T-38 Forward Windshield Frame Dimensions

Because of the unsuccessful attempt to install prototype D/OT&E item and initiation of auxiliary air door modification test program, SA-ALC decided not to undertake D/OT&E of the T-38 bird impact resistant panel. Redirection of SA-ALC local RDT&E program and reevaluation of development test responsibilities were reasons given for this decision. SA-ALC was still vitally interested in this program and pledged logistical assistance to support the D/OT&E program. Although SA-ALC had made commitments and had an approved test plan by the Flight Safety Review Board, WL/FIVR was informed that ALC aircraft would not be available for D/OT&E.

NASA Langley cooperation (3.0 NASA Special Windshield) avoided extensive contractual delays. Completion of flight demonstrations proposed and directed by Mr. Bob Pinnell was completed by NASA, instead of SA-ALC as originally planned. When NASA completed flight demonstrations, there was no basis for flight restrictions or redesign of transparency system. This transparency system was certified as safe for conducting the OT&E. WL/FIVR advised SA-ALC to begin shipping the first of seven frames for modification of Air Training Command (ATC) aircraft.

5.0 OPERATIONAL TEST AND EVALUATION (OT&E)

As discussed in the D/OT&E section, SA-ALC agreed to support the OT&E testing. In accordance with this support they would arrange for removal of frames from aircraft, removal of acrylic panels, nondestructive inspection (NDI) of frames, supply of primers and paints, shipment to PPG Industries every 2-weeks until seven parts were shipped, and reinstallation on the aircraft when the bird impact resistant transparent system was returned. PPG Industries, Huntsville, estimated a 45-day turnaround to allow for weighing and measuring frame, shipment to UDRI for composite aft arch fabrication, return shipment to PPG for weighing and measuring, installation of transparent panel, weighing and measuring, final inspection, and shipment back to Randolph Air Force Base. All installations were accomplished at Queen Bee Hanger, Randolph Air Force Base, and performed by Lier Sigler Company (Air Force maintenance contractor). See Table 2 for base locations, aircraft identifications, date received at PPG, and date returned to Randolph Air Force Base.

See Appendix D for instruction package supplied by SA-ALC Engineering to assist in maintenance of the new transparent system. It also contains pertinent information about cleaning, removal, installation, reporting forms, and warning sign.

See Figures 7, 8, and 9 and Table 3 to document all weights and measurements of flight quality frames received, modified, and installed.

The first installation of the first bird impact resistant OT&E item occurred during the week of June 16, 1986. The second installation was about 75 percent completed the same week. Since the OT&E was based on frames being removed from the same aircraft they were being reinstalled on, and careful

TABLE 2

BASE LOCATIONS AND AIRCRAFT IDENTIFICATION

T-38 BIRD RESISTANT WINDSCREEN TEST PROJECT

AIRCRAFT TAIL NO.	BASE	DATE RECEIVED	DATE RETURNED
62-3721	Vance	4/16/86	6/2/86
66-8402	Randolph	4/29/86	6/12/86
64-13251	Laughlin	5/7/86	6/26/86
61-0849	Columbus	6/9/86	7/28/86
62-3616	Williams	6/26/86	8/18/86
62-3681	Reese	6/26/86	8/27/86
62-3750	Sheppard	7/23/86	10/9/86

Table 2. Base Locations and Aircraft Identification

Table 3. OT&E Frame Measurements and Weights

TAIL # 3721																							
FRAME # 5480	WEIGHT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
AS RECEIVED	19.00	31.56	33.97	33.88	36.75	19.06	28.06	28.75	29.13	29.50	29.81	29.97	30.19	19.03	18.69	17.88	16.50	14.88	19.00	18.69	17.88	16.50	15.00
ARCH INSTALL # 15	25.50	31.90	33.91	33.88	36.69	18.95	28.20	28.85	29.45	29.85	30.20	30.50	30.53	18.90	18.62	17.88	16.60	15.08	18.85	18.50	17.80	16.51	15.12
PANEL INSTALL #342-5	75.50	31.75	33.91	33.88	N/A	18.92	28.38	28.90	29.50	29.81	30.18	30.38	30.38	18.90	18.65	17.90	16.58	15.02	18.81	18.45	17.75	16.45	15.06
TAIL # 8402																							
FRAME # 15987	WEIGHT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
AS RECEIVED	19.90	31.50	33.95	33.94	36.53	19.10	28.28	28.75	29.20	29.60	29.90	30.10	30.15	18.95	18.60	17.90	16.60	15.00	18.95	18.55	17.87	16.42	15.02
ARCH INSTALL # 16	26.60	31.87	33.95	33.94	36.53	19.05	28.28	28.80	29.28	29.75	30.05	30.35	30.54	18.91	18.62	17.93	16.66	15.12	18.87	18.45	17.80	16.50	15.10
PANEL INSTALL #342-6	77.20	31.80	33.95	33.94	N/A	19.05	28.30	28.83	29.30	29.78	30.07	30.33	30.46	18.95	18.66	17.95	16.68	15.14	18.89	18.45	17.75	16.43	15.05
TAIL # 13251																							
FRAME # 1551	WEIGHT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
AS RECEIVED	19.80	31.55	33.86	33.90	36.20	19.05	28.42	28.90	29.30	29.70	29.92	30.05	30.10	18.95	18.60	17.89	16.55	14.95	18.95	18.55	17.77	16.40	14.95
ARCH INSTALL # 17	26.00	31.90	33.86	33.90	36.35	19.05	28.40	28.95	29.45	29.87	30.15	30.40	30.57	18.90	18.59	17.88	16.60	15.07	18.95	18.57	17.83	16.52	15.10
PANEL INSTALL #342-6	76.20	31.80	33.86	33.90	N/A	19.05	28.35	28.90	29.40	29.75	30.00	30.30	30.40	18.91	18.58	17.88	16.58	15.01	18.95	18.54	17.76	16.44	15.03
TAIL # 0849																							
FRAME # 5218	WEIGHT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
AS RECEIVED	18.50	31.50	33.90	33.83	36.27	19.10	28.10	28.80	29.20	29.50	29.80	30.00	29.95	18.95	18.60	17.85	16.42	14.89	18.98	18.60	17.85	16.43	14.95
ARCH INSTALL # 18	25.70	31.42	33.90	33.83	36.31	19.13	28.10	28.78	29.17	29.46	29.75	29.95	29.90	19.03	18.65	17.85	16.41	14.85	19.03	18.59	17.79	16.34	14.85
PANEL INSTALL #342-5	75.60	31.42	33.90	33.83	N/A	19.15	28.13	28.78	29.18	29.50	29.76	29.96	29.87	19.04	18.65	17.82	16.40	14.82	19.05	18.61	17.80	16.32	14.86
TAIL # 3616																							
FRAME # 4320	WEIGHT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
AS RECEIVED	18.70	31.60	33.88	33.84	36.47	19.10	28.35	28.85	29.30	29.65	29.95	30.08	29.90	19.00	18.65	17.92	16.55	14.89	18.96	18.59	17.78	16.34	14.85
ARCH INSTALL # 19	26.00	31.61	33.88	33.84	36.47	19.15	28.35	28.86	29.30	29.65	29.96	30.06	29.90	19.03	18.70	17.90	16.54	14.88	19.05	18.60	17.74	16.28	14.83
PANEL INSTALL #342-6	76.50	31.63	33.88	33.84	N/A	19.15	28.35	28.88	29.32	29.68	29.95	30.08	29.93	19.03	18.68	17.84	16.45	14.87	19.03	18.58	17.74	16.30	14.85
TAIL #3681																							
FRAME # 1576	WEIGHT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
AS RECEIVED WEIGHT AND MEASUREMENTS NOT TAKEN REPLACEMENT FRAME FOR CORRODED FRAME REJECTED																							
ARCH INSTALL # 14	25.50	31.80	33.86	33.84	36.43	19.10	28.32	28.90	29.35	29.75	30.02	30.25	30.40	19.00	18.68	17.90	16.65	15.05	18.95	18.54	17.77	16.38	15.00
PANEL INSTALL #342-5	75.00	31.70	33.86	33.84	N/A	19.10	28.32	28.90	29.38	29.75	29.98	30.20	30.25	18.98	18.63	17.85	16.62	14.98	18.98	18.53	17.76	16.40	15.02
TAIL # 3750																							
FRAME # 5456	WEIGHT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
AS RECEIVED	19.50	31.57	33.85	33.81	36.52	19.05	28.20	28.75	29.30	29.62	29.95	30.07	30.15	18.96	18.60	17.80	16.50	14.90	18.90	18.52	17.73	16.35	14.92
ARCH INSTALL # 20	26.90	31.40	33.85	33.81	36.52	19.13	28.22	28.75	29.25	29.52	29.80	29.98	30.00	19.00	18.63	17.78	16.42	14.85	19.00	18.58	17.70	16.25	14.80
PANEL INSTALL #342-1	77.50	31.35	33.85	33.81	N/A	19.15	28.20	28.80	29.35	29.67	29.89	29.99	29.92	19.05	18.63	17.78	16.42	14.80	19.05	18.60	17.70	16.22	14.80
AVG WEIGHT AS RECEIVED		19.2	LBS	MAXIMUM WEIGHT AS RECEIVED					19.9	LBS		MINIMUM WEIGHT AS RECEIVED				18.5	LBS		VARIAN		1.4	LBS	
AVG WEIGHT ARCH INSTALL		26	LBS	MAXIMUM WEIGHT ARCH INSTAL					26.9	LBS		MINIMUM WEIGTH ARCH INSTAL				25.5	LBS		VARIAN		1.4	LBS	
AVG WEIGHT ASSEMBLY		76.2	LBS	MAXIMUM WEIGHT ASSEMBLY					77.5	LBS		MINIMUM WEIGHT ASSEMBLY				75	LBS		VARIAN		2.5	LBS	

before and after modification measurements were made, no major aircraft fit problems were expected or encountered. PPG Project Engineer, Mr. James Myers, was on site to assist with installation of the first two units.

Nondestructive inspection (NDI) performed at Randolph Air Force Base to assure structural integrity of the magnesium frame resulted in the rejection of the frame from aircraft 3681, based at Reese Air Force Base. Comparative measurements of this frame and a spare frame that had not been expended during bird impact testing indicated this frame could be used as a substitute for the rejected frame. After shipment to Randolph Air Force Base for fit confirmation and piano hinge installation, the frame was returned to PPG and a bird impact resistant panel installed.

Field service was provided at Randolph Air Force Base to correct a problem with the forward bottom section of the add-on composite arch on the first two installations (aircraft 62-3721 and 66-8402). This section of the arch is nonstructural as related to bird impact resistance. An application of epoxy was made to this area as a filler patch because the bolt hole location was close to the composite edge. The epoxy used was not designed to be used for the thickness required for this patch. Also the angularity of the bolt in that hole caused a stress point and contributed to cracks in the epoxy patch. To remedy this problem, replacement of the patch material was with Ren Plastic Fast Weld Epoxy No. 10. In addition the subject holes were then drilled oversize and an aluminum bushing potted in place, bottoming against the inside magnesium frame. This bushing was then spot-faced to the hole ensureing correct angle for washer and nut. This also ensured that the clamping load was taken off the nonstructural area of the epoxy patch. Aircraft 64-13251 was examined and this

condition did not exist because of corrective action taken during the composite manufacturing lay-up. Additional material was added to all remaining OT&E units.

During the final installation effort of the first unit at Randolph, fasteners securing the transparent panel to the frame did not protrude through its self-locking nut sufficiently to expose two full threads. Since this condition was outside acceptable specifications for airframe fasteners, a waiver was necessary to proceed with the installation. The waiver was based on low-torque (50-inch-pounds) and resulting low tensile loading in the fastener (1/4-inch bolt). Conditions attached to the waiver required that the bolt be retorqued every 50 flying hours. The installation torque was low for these bolts compared to normal torque (125-inch-pounds), because the transparent polycarbonate laminate clamped by the bolt includes a soft inner layer which distorts when excessively compressed. All later OT&E installation met the two-threads-exposure criteria before installation. Meeting the criteria require the use of two custom fit 1/4-inch bolts for each installation to attach the stand by magnetic compass bracket. No other problems were noted during OT&E unit installation.

Upon release from Randolph Air Force Base, Functional Check Flight (FCF), the aircraft were returned to their respective bases and scheduled for normal operational flights. Crew debriefing forms were forwarded monthly to PPG Industries for tallying flight hours and summarizing crew debriefings. Final installation of the seventh bird impact resistant system on aircraft 62-3750 occurred in October, 1986, and was the last aircraft released to ATC. Besides monthly summaries submitted from each base, PPG Industries made two on-site inspections of each individual bird impact resistant transparent system. The first inspections were between March 26, 1987, and April 9, 1987, summarization follows.

5.1 Individual Inspections

5.1.1 Columbus Air Force Base - Tail #0849

Student windshield has a scratch on inboard PPG 8500 surface, port sill location, approximately 2-inches long and 1/8-inch to 3/16-inch wide. This scratch was made by a clipboard or ring binder causing no damage to the polycarbonate.

5.1.2 Vance Air Force Base - Tail #3721

Student windshield has two small scratches on inboard PPG 8500 surface very similar to Columbus. Some bolts have been retorqued.

5.1.3 Williams Air Force Base - Tail #3616

Many small scratches and nicks noted on inboard PPG 8500 surface. Again, scratches appear to be caused by ring binder or clipboard. One small 0.06-inch diameter, light brown spot in PPG 5300 liner just right of centerline has not changed since fabrication.

5.1.4 Randolph Air Force Base - Tail #8402

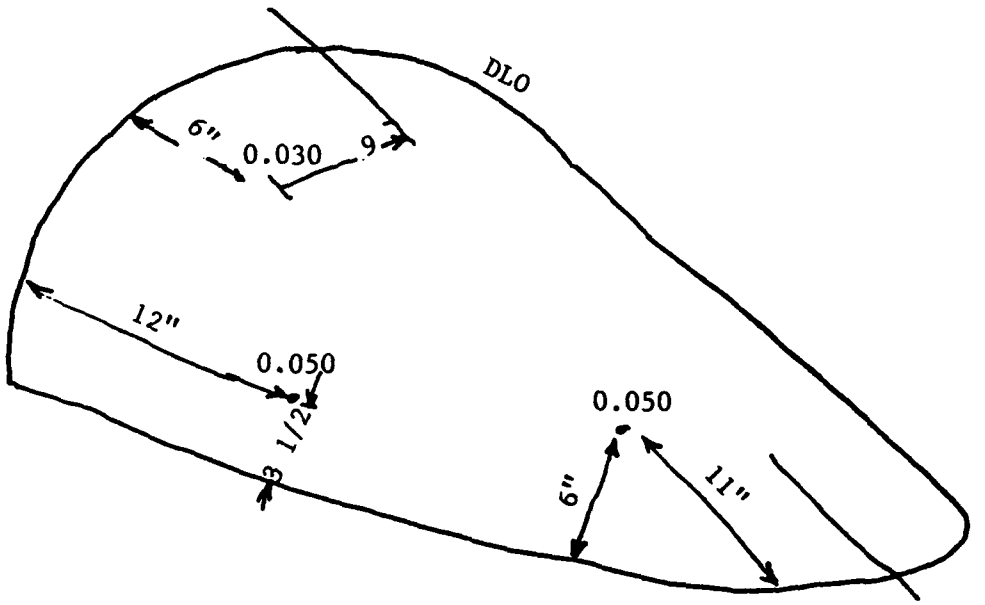
Many rubs on PPG 8500 inboard surface, but no scratches. A good cleaning removed all marks.

5.1.5 Laughlin Air Force Base - Tail #3251

No problems with windshield. Very clean windshield.

5.1.6 Reese Air Force Base - Tail #3681

No change in PPG 5300 liner small bubbles noted during manufacturing (Figure 10). Very clean windshield.



BUBBLES IN 5300 LINER

S-14 342-54

Figure 10. Bubbles In 5300 Liner (S-14 Serial #342-54)

5.1.7 Sheppard Air Force Base - Tail #3750

Recent cut in PPG 5300 liner 5 1/4-inches forward of aft fairing and up from left sill 6 1/2-inches approximately 2 1/4-inches long. Cause unknown, but made by very sharp object. Location of cut was not a critical visual area and structural damage not evident; aircraft will continue to fly. Small dimple in PPG 5300 liner forward of compass area; no change since manufacture.

None of the transparencies showed any signs of crazing, cracking, delamination, debonding of the liner, or yellowing. Besides the inspections, briefings and debriefings were held at every base with maintenance personnel, crew chiefs, flight safety personnel, instructors, students, pilots, and ATC personnel. Items covered included the following:

1. Correct cleaning procedures.
2. Samples of cross sections: windshield and composite arch.
3. Comments from instructor pilots and pilots.
4. Review of individual rating (monthly summaries).
5. Discussions on problem areas.

6.0 REVIEW OF T-38 PROGRAM AND TESTING FOR ATC BASES

Several bases requested VHS films of T-38 bird strike impact testing for review and educational purposes at their safety meetings. A VHS tape showing a failure and some of the Flight Quality Qualification Test Impacts was distributed to the seven ATC bases.

During inspections it was discovered that Randolph Air Force Base (ATC Headquarters) had restricted flying to daytime only, because of decreased vision caused by composite arch reinforcement. Following are results of a flight by Captain Schavrien, T-38 Flight Safety Project Officer, and Major St. Sauver of ATC Flight Safety Office.

- Major St. Sauver and Captain Schavrien flew Randolph Air Force Base aircraft 8402 on June 15, 1987. This flight was a day/night, out and back to Kelly Air Force Base to pinpoint problem areas and relay them to PPG Industries.

- Captain Schavrien flew both legs, in the rear cockpit and noted several problem areas. During day flights the beefed up bow presented some visual problem because of its size, but nothing that could not be handled. Some distortion was observed when looking through windscreen near the edges. Distortion was about even with mirrors in front cockpit. Tape or paint band may cover this distortion as the windscreen has a bigger viewing area than production acrylic unit. Night flights determined bow area to be the major problem. The bow completely blocks out the landing threshold area until in the flare. By putting (viewing) bow on threshold, you are forced to look above bow. This part of the canopy, not the windscreen, has distortion and Captain Schavrien had double image problems with the vasis.

- Major St. Sauver complained of visual problems from the front seat. Areas 1 and 2 (Figure 11) were distorted causing the ground to ripple as observed from front cockpit only. At night, the lights would twinkle as they passed through these areas. During transition to flair, it was very difficult to judge depth perception because of this distortion. If covered without correction, downward visibility would be greater reduced. The pitok tube, which is visible on aircraft with old windscreens, could not be seen as it connects to aircraft nose.

- Flight Safety Office recommendation was to continue next generation composite bow development (Figures 12, 13, and 14), Visibility Impact Comparison. After new bow is installed with possible painting or taping of certain areas that have visual distortions, the new windscreen should be further evaluated.

- On July 22, 1987, PPG Industries provided the following list of items to help in painting a black band in the reverse curvature area on seven T-38 OT&E test windscreens.
    - Width of sill area to be painted, 1.25-inches maximum, 1-inch minimum.
    - Paint flat black antiglare #37038.
    - MIL-C-83286 (FSN 8010000822450).
    - Use plain paper or kraft paper to cover windscreen during painting. Do not cover windscreen with bullhide or any type masking material.
    - Masking tape may be used to define area to be painted.
    - Remove tape after painting, preferably as soon as possible, but not more than 1-hour after applying.

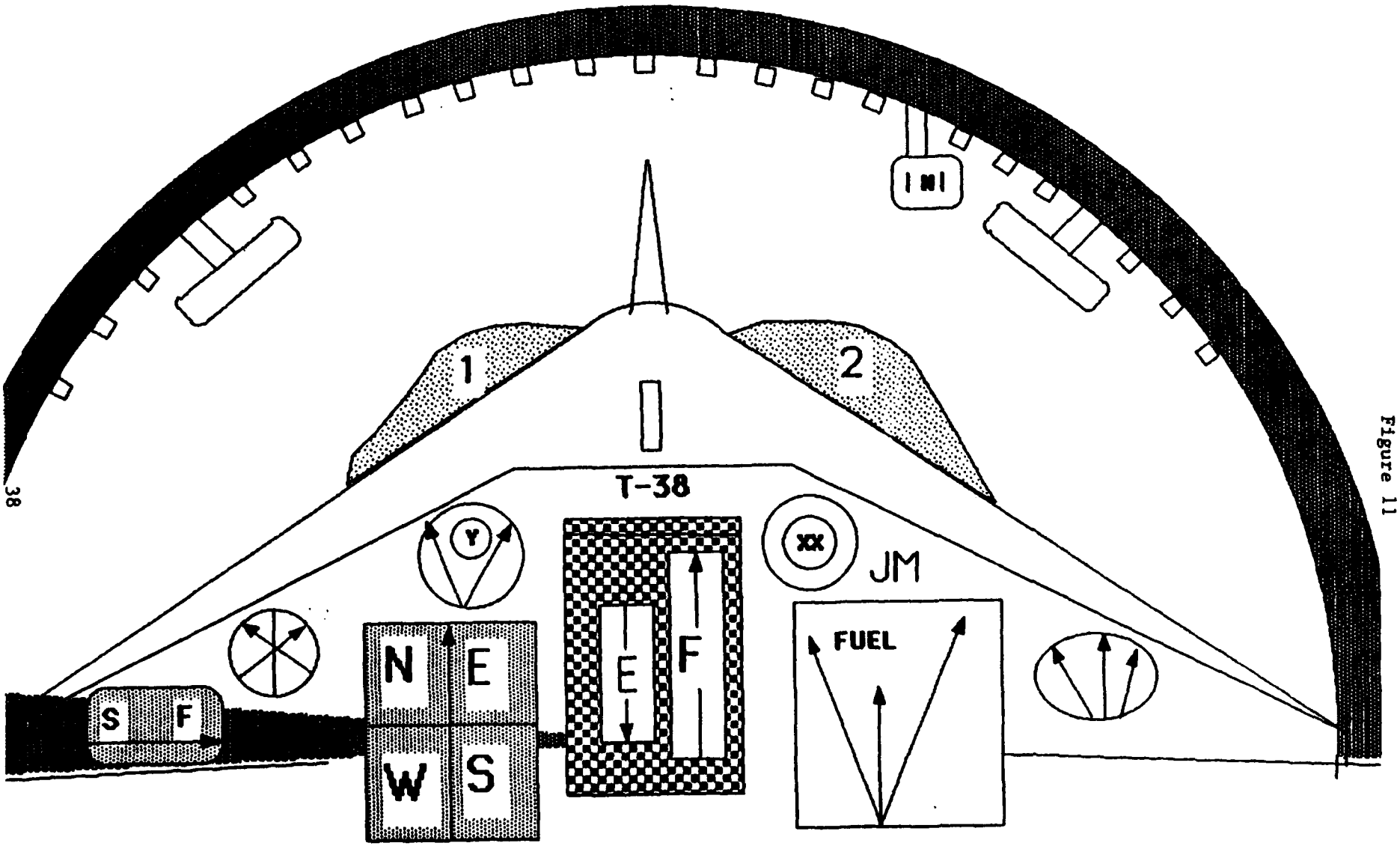
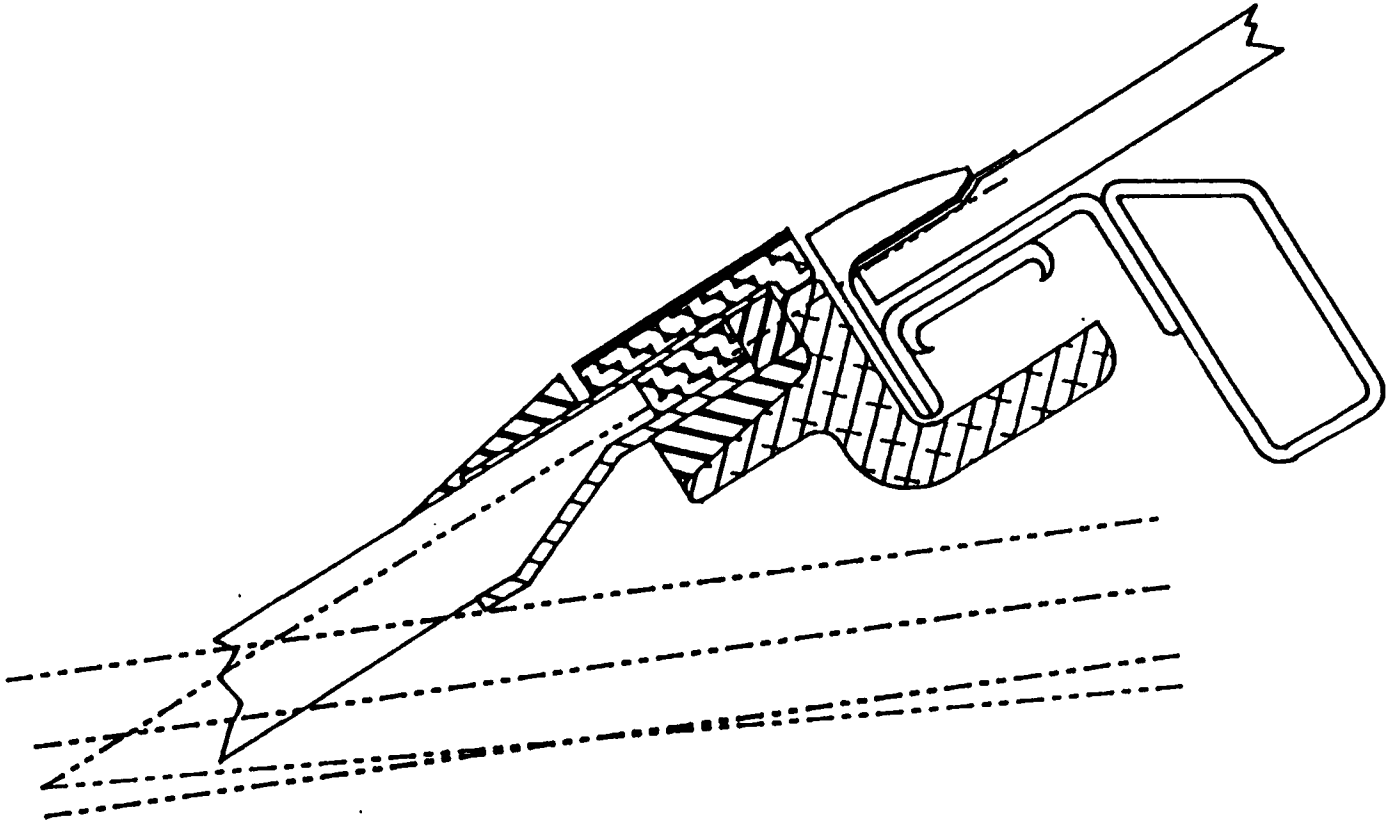
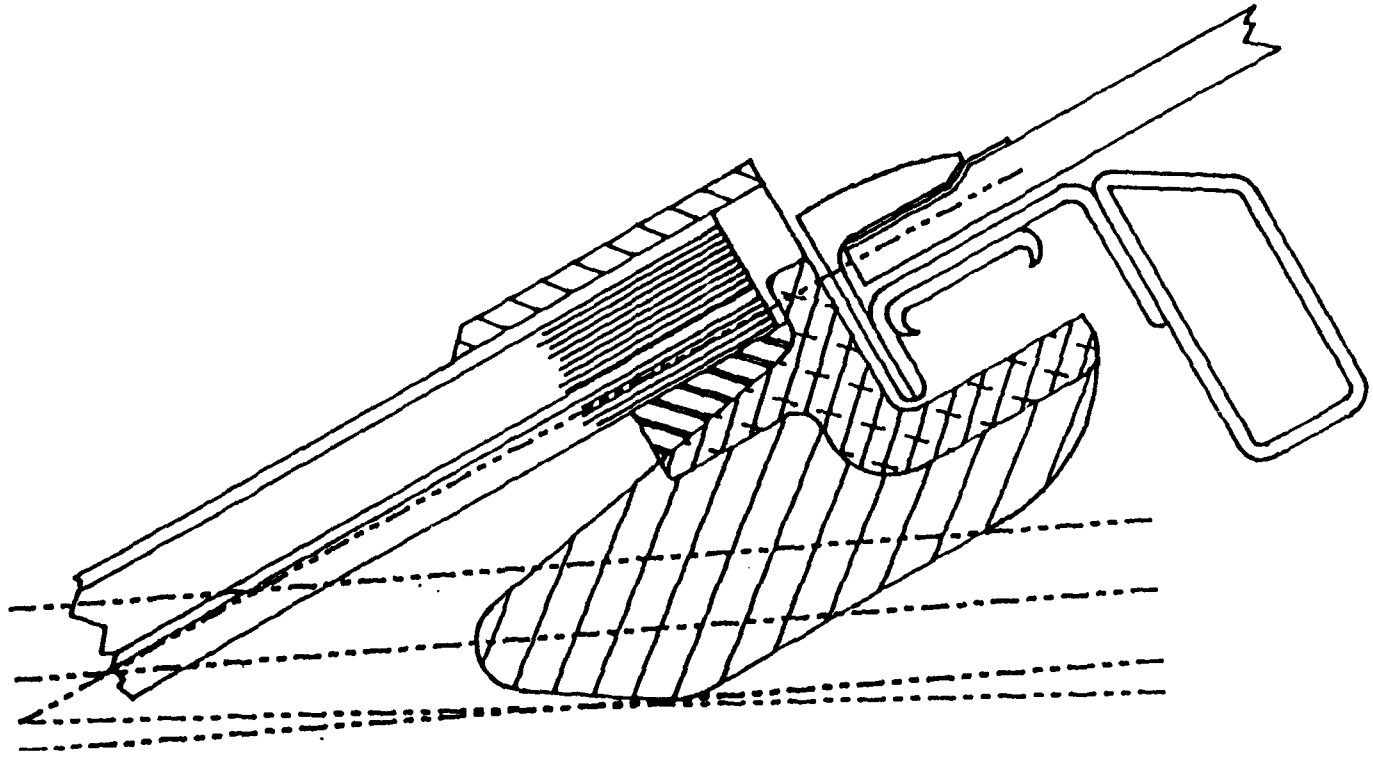


Figure 11. Pilot View Of Forward Windshield



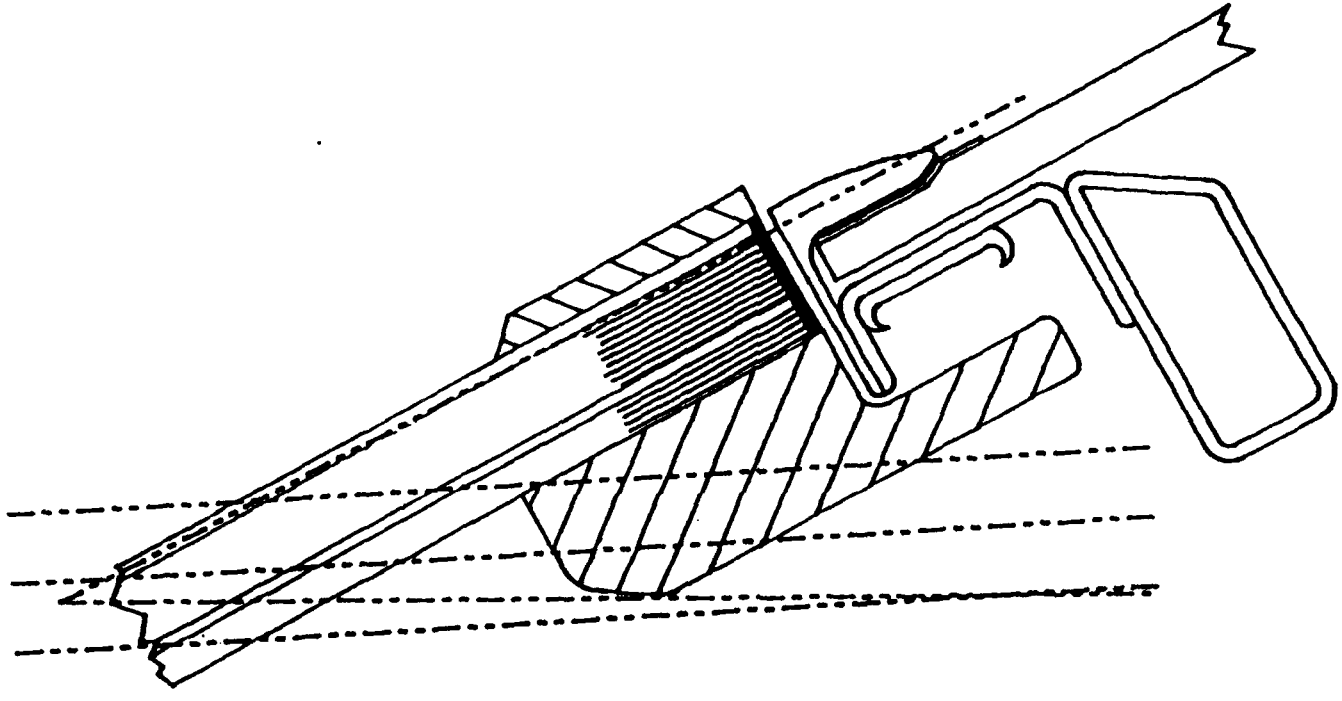
ORIGINAL MAGNESIUM CASTING
WITH STANDARD WINDSHIELD

Figure 12. Visibility Impact Comparison



HYBRID COMPOSITE BOW REINFORCEMENT
WITH NEW BIRD RESISTANT WINDSHIELD

Figure 13. Visibility Impact Comparison



COMPOSITE BOW AS DEPICTED FOR 1ST DESIGN REVIEW WITH NEW BIRD RESISTANT WINDSHIELD

Figure 14. Visibility Impact Comparison

- o Clean area to be painted with 50/50 cleaning solution before painting.

It was thought that by painting this band around windscreen edge, it would simulate daylight opening (DLO) more closely than old style acrylic units with edge attachment. Unfortunately no documentation was received to determine exactly when this band was installed. Since July 1987, was the last official month for flight reporting, additional reporting time was requested. Several bases did continue through September 1987, but it was unknown if the paint band had been applied.

Summarization of pilot debriefing reports, actual flight hours, pilot ratings, and comments are shown in Table 4. Individual base reports, actual flight hours, pilot ratings, and comments are summarized in Appendix E. Reporting time periods vary per individual aircraft, some start as early as August 1986, with the latest reports through September 1987.

Table 4. T-38 Flight Test Summary

	T-38 DEBRIEFING SUMMARY ALL AIRCRAFT				
	DATE	AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP			
TOTAL FLIGHT TIME HRS:		1661			
		COMPARISON			
		MULTIPLE			
	DISTORTION	IMAGES	REFLECTIONS	HAZE	OVERALL
MUCH BETTER	64	78	83	82	78
BETTER	201	190	264	239	273
SAME	709	1096	921	904	663
WORSE	430	105	205	223	403
MUCH WORSE	128	47	53	49	115
TOTAL NUMBER OF REPORTS		1522			

7.0 OPERATIONAL TEST AND EVALUATION PROBLEMS

On June 8, 1987, there were cracks reported in the transparent panel of aircraft 3721, Vance Air Force Base. PPG Industries Project Engineer, Mr. James Myers, examined these cracks on June 16, 1987. Two cracks were present, originating at the first forward bolt hole in the right aft corner. The crack nearest twelve o'clock position was 1.5-inches long, and located in 3/16-inch inner polycarbonate ply. The second crack was at the 2 o'clock to 3 o'clock position, 2-inches long and located in 3/8-inch outer polycarbonate ply. Neither crack broke the surface or was through the inner layer. Cause of cracks appeared to be bolt over torquing. Since cracks were not in the same location and did not extend into the DLO, they were normally not visible. Structurally the windshield was sound, could handle pressure loads, and any impact loads for which it was designed. During developmental and qualification testing, several windshields had cracks in the primary vision area larger than 5-inches and some cracks the length of the windshield. These test windshields were impacted multiple times in different locations at 400-knots and in all cases met bird impact requirements. Permission was given to continue flying aircraft with progression monitoring for continued crack propagation. A limit of 6-inches was set as the maximum length of crack, before aircraft would be grounded and windshield replaced. The unit continued to fly through October, 1987, and was replaced in November, 1987.

On August 4, 1987, cracks were reported in aircraft 3681 transparent panel, Reese Air Force Base. PPG Industries Project Engineer, Mr. James Myers, examined these cracks August 11, 1987. Upon visual inspection a crack was viewed from the outside and two smaller cracks viewed from the inside. The large crack was approximately 2.2-inches long and originated from the second bolt hole on forward fairing left side. Two small cracks also originated at the same bolt hole.

All cracks were in the 3/16-inch polycarbonate ply and none of the cracks broke the surface or was through the inner layer. Again permission was given for continued aircraft flight. Cracks were monitored for propagation and further propagation was not reported. This unit continued to fly during June, 1989.

January 1988, Columbus AFB, tail #0849, unit returned with PPG 8500 inboard coating problem. Coating appeared to be cleaned with a dry and dirty cloth resulting in fine scratches in the PPG 8500 surface. Scratches were polished and unit returned to service.

February 1988, Sheppard AFB, tail #3750, reported cracks at bottom aft bolt holes. Unit was inspected and permission to fly with progression monitoring granted.

March 1988, Sheppard AFB, tail #3750, reported urethane paint over spray on outside surface of windshield (PPG 5300 liner). Aircraft will continue to fly unless visibility restricted.

April 25, 1988, Vance Air Force Base, tail #3721, a crack was reported in replacement windshield. Crack location described was up rear arch at the third bolt hole and extending forward approximately 2-inches. This bolt carries wire clip for the magnetic compass and it had been retorqued, probably causing crack. Because of location and size of crack, permission was given to continue flying aircraft. This crack was not examined by PPG Industries personnel. Crack was monitored for propagation by Vance AFB maintenance personnel, and no further crack propagation has been reported. This unit continued flying during June 1989.

May 1988, Sheppard Air Force Base, tail #3750, windshield replaced because of paint over spray reported in March 1988. September 1988, Reese Air Force Base, tail #3681, some

peeling of PPG 8500 inboard coating, no problem with crack propagation, and aircraft will continue to fly.

November 1988, Randolph Air Force Base, tail #8402, windshield replaced for milky and hazy (bloom) condition of PPG 8500 inboard coating.

December 1988, Laughlin Air Force Base, tail #3251, windshield replaced for milky and hazy (bloom) condition of PPG 8500 inboard coating.

January 1989, Columbus Air Force Base, tail #0849, windshield replaced for milky and hazy (bloom) condition of PPG 8500 inboard coating.

March 1989, Williams Air Force Base, tail #3616, windshield replaced for milky and hazy (bloom) condition of PPG 8500 inboard coating.

8.0 FINAL FIELD INSPECTIONS OF OT&E INDIVIDUAL UNITS

8.1 Individual Reports

The following individual reports cover final inspection of the seven OT&E test windshields, at their respective bases in December 1987.

8.1.1 Columbus Air Force Base - Tail #0849

Reported 120.4 flying hours. Student windscreen has many scratches on PPG 8500 inboard surface coating, left sill area, caused by clipboard, knee board, or maintenance binder. There is no damage to the polycarbonate structural ply. There has been some flaking of PPG 8500 coating from a scratch that was inspected in March 1987.

8.1.2 Vance Air Force Base - Tail #3721

Reported 215.1 flying hours on original unit. Student windscreen was replaced in early November 1987, because of polycarbonate cracks.

8.1.3 Williams Air Force Base - Tail #3616

Reported 267.5 flying hours. Student windscreen has many small scratches and nicks on PPG 8500 inboard surface coating, left sill area. Very little change since April inspection. Many small rubs on PPG 8500 surface were removed by cleaning.

8.1.4 Randolph Air Force Base - Tail #8402

Reported 125.1 flying hours. Student windscreen has many rubs on PPG 8500 inboard surface coating, left sill area. All rubs can be removed by cleaning.

8.1.5 Laughlin Air Force Base - Tail #3251

Reported 444 flying hours. Student windscreen has two small cracks in left sill area, at first and second #10 bolt holes, also three small cracks in right-hand nose area under front fairing. None of the cracks extend into the DLO and all appear to be in the 3/16-inch polycarbonate ply. Cracks were not reported, but discovered during inspection. Permission was given to continue flying aircraft with windscreen monitoring by Chief Rydzfski. Continued crack propagation would result in windscreen replacement.

8.1.6 Reese Air Force Base - Tail #3681

Reported 263.9 flying hours. Student windscreen has three small cracks originating from second bolt hole on forward fairing left side. All cracks are in the 3/16-inch polycarbonate ply and no cracks break the surface. These cracks were reported in early August and after examination, permission was granted for continued flight. In mid October, PPG again checked cracks, which showed no propagation. There is a scratched area on PPG 8500 coating located midway on left sill area. Damage was erratic for 3 1/2-inches and the PPG 8500 coating removed from two areas 1/4-inch wide by 1-inch long and 1/8-inch wide by 3/4-inch long. Close visual and magnified inspection confirmed no polycarbonate ply damage. Again permission was given to fly, barring any complaints for optical problems.

8.1.7 Sheppard Air Force Base - Tail #3750

Reported 225.1 flying hours. Student windscreen showed significant healing to damaged area of PPG 5300 liner inspected in April. A reported

spotting problem on PPG 8500 coating was inspected. It appeared as a small dimple like mark in a 12-inch band running from right-to-left and approximately 12-inches forward of aft arch. This condition was not visible to pilots and could only be seen at severe viewing angles, when not looking directly into a light source. Permission was given to continue flying.

None of the windshields showed any problems with PPG 5300 outboard liner. Since manufacturing, documented small bubbles and spots in PPG 5300 liner have caused no problems, nor have they changed since installation.

PPG Industries recognized problems with PPG 8500 inboard coating (peeling, delamination, hazing, and scratching) and use of PPG 8500 coating was discontinued. A new abrasion resistant coating PPG 9350 was qualified for use on F-111 aircraft. This coating was used on the Vance AFB replacement as inboard abrasion resistant coating. PPG 9350 coating would be used on all future T-38 parts as inboard abrasion resistant coating.

9.0 OPTICS

Transparencies produced under this program met Acceptance Test Procedure (ATP) requirements. PPG Industries conducted inspections, as necessary to declare whether transparencies met the optical flight quality test requirement before delivery.

9.1 Individual Inspections

Each individual transparency was inspected for both major and minor defects (cracks, chips, gouges, scratches, embedded particles, bubbles, seeds, surface dimples, deviation, distortion, haze, and transmissivity). A summary of each transparency by aircraft number and PPG serial number is listed in Table 5. Individual photographs of installed transparencies follow in Figures 15 through Figure 32. A legend is shown on the photograph.

9.2 Optical Test Windshield

PPG supplied WPAFB with transparency Serial No. 87-H-03-22-064 for optical testing. These tests were performed during May 11 through May 22, 1987. Due to WPAFB windscreen test facility construction, tests results were not as controlled or precise as in the past, nor were all tests normally conducted administered. The following tests were performed and results, as well as test description follow. All testing was performed by Mr. Bill Kama and Mr. Lee Task of AAMRL/HEF.

9.3 Minor Defects

This test involved looking through windscreen at a well lit background (in this case, outdoors in sunlight) to determine the presence of any blemishes or defects (scratches, bubbles, inclusions, etc.) on surface or within the windscreen itself.

Table 5. T-38 Student Windshield
Optical Evaluation

AIRCRAFT NO.	PPG W/S SERIAL NO.	STUDENT POSITION DEVIATION		INSTRUCTOR POSITION DEVIATION	
		DV CRITICAL	DV SEMI-CRITICAL	DV CRITICAL	DV SEMI-CRITICAL
YANCE #62-3721	86-H-05-10-238	0.80	0.80	0.80	1.20
RANDOLPH #66-8402	86-H-06-01-227	0.65	0.80	0.90	1.10
LAUGHLIN #64-13251	86-H-06-15-202	1.00	1.00	1.00	1.20
COLUMBUS #61-0849	86-H-07-13-234	1.00	0.80	1.00	1.15
WILLIAMS #62-3616	86-H-08-10-051	1.25	1.00	1.50	1.20
REESE #62-3681	86-H-08-24-032	0.85	0.80	1.00	1.10
SHEPPARD #62-3750	86-H-10-05-001	1.30	1.00	1.40	1.20
AIRCRAFT NO.	PPG SERIAL NO.	LINE/SLOPE DISTORTION			
		CRITICAL	SEMI-CRITICAL		
YANCE #62-3721	86-H-05-10-238	1:14	1:17		
RANDOLPH #66-8402	86-H-06-01-227	1:12	1:10		
LAUGHLIN #64-13251	86-H-06-15-202	1:16	1:12		
COLUMBUS #61-0849	86-H-07-13-234	1:13	1:11		
WILLIAMS #62-3616	86-H-08-10-051	1:14	1:08		
REESE #62-3681	86-H-08-24-032	1:12	1:18		
SHEPPARD #62-3750	86-H-10-05-001	1:16	1:16		
AIRCRAFT NO.	PPG SERIAL NO.	% LIGHT TRANSMISSION	% HAZE TRANSMISSION		
YANCE #62-3721	86-H-05-10-238	86.10	0.80		
RANDOLPH #66-8402	86-H-06-01-227	85.30	1.00		
LAUGHLIN #64-13251	86-H-06-15-202	85.60	0.80		
COLUMBUS #61-0849	86-H-07-13-234	84.60	0.80		
WILLIAMS #62-3616	86-H-08-10-051	85.80	1.30		
REESE #62-3681	86-H-08-24-032	85.70	1.40		
SHEPPARD #62-3750	86-H-10-05-001	86.50	0.30		
	AVERAGE	85.66	0.91		
	VARIANCE	0.36	0.13		
	STD DEVIATION	0.60	0.37		

CODE: T-38
SERIAL: 86-H-05-10-238
DATE: 5-14-86
POSITION: Instructor
STAGE: Prefinish Optical

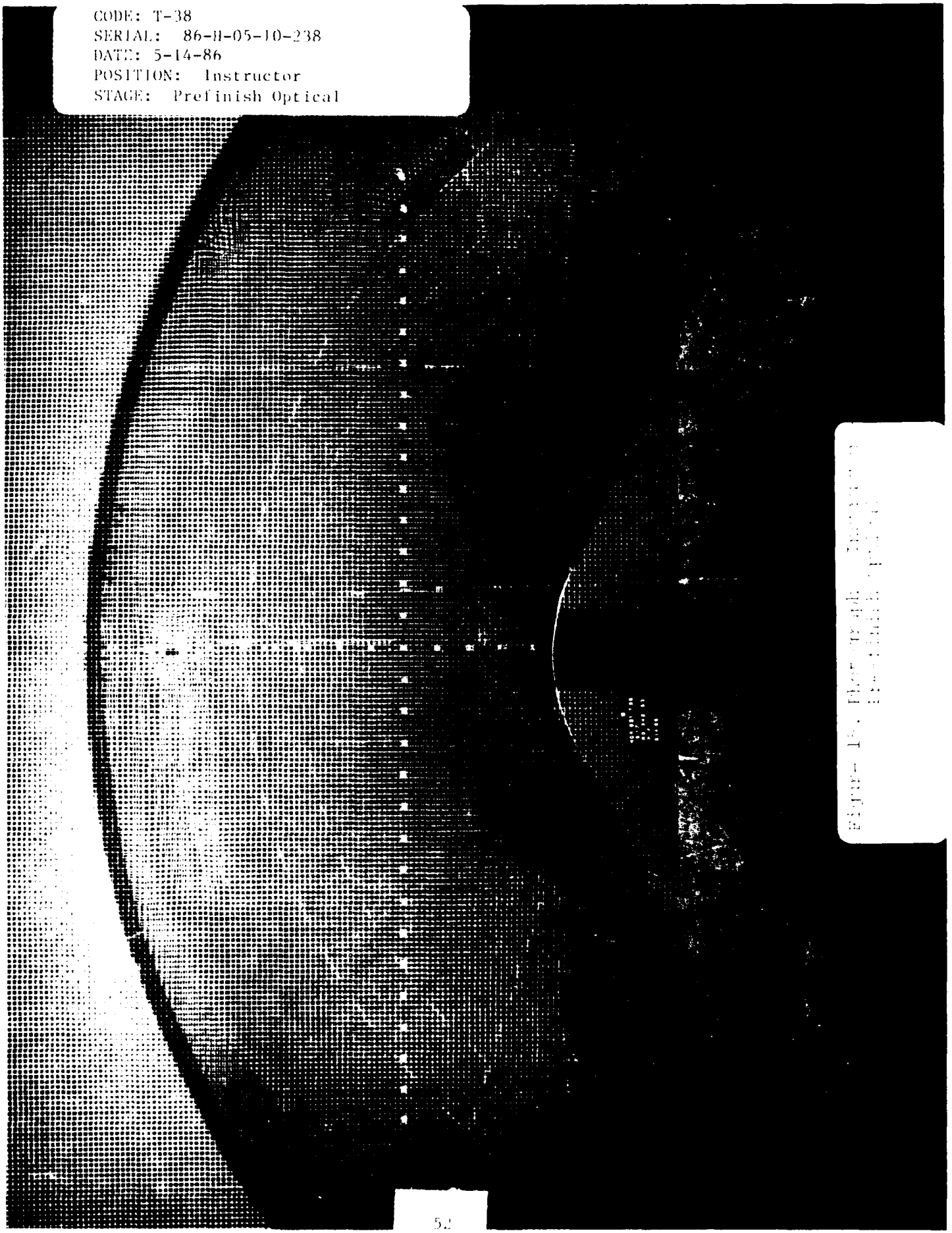


Figure 1. Photograph [illegible]

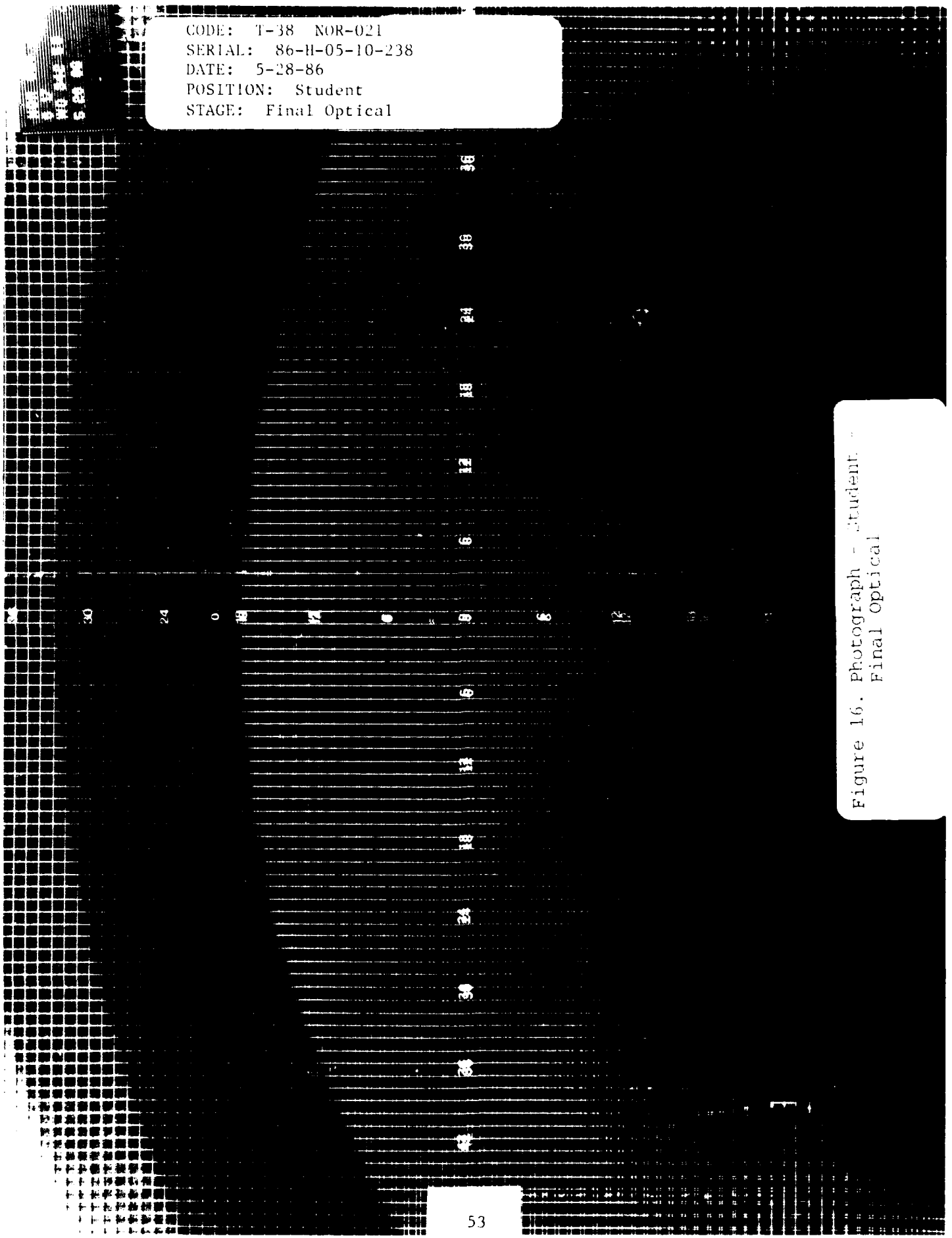


Figure 16. Photograph - Student
Final Optical

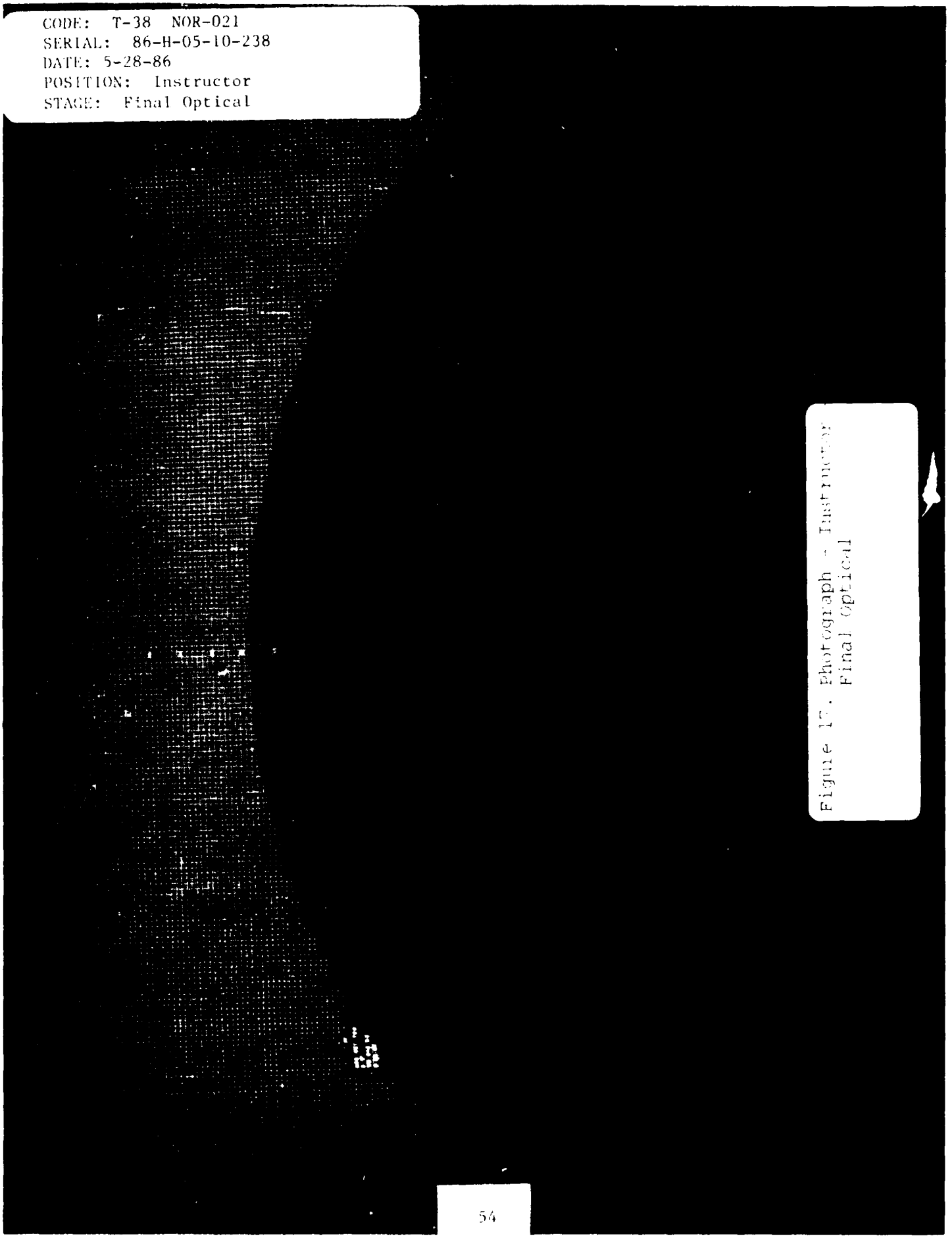


Figure 17. Photograph - Instructor Final Optical

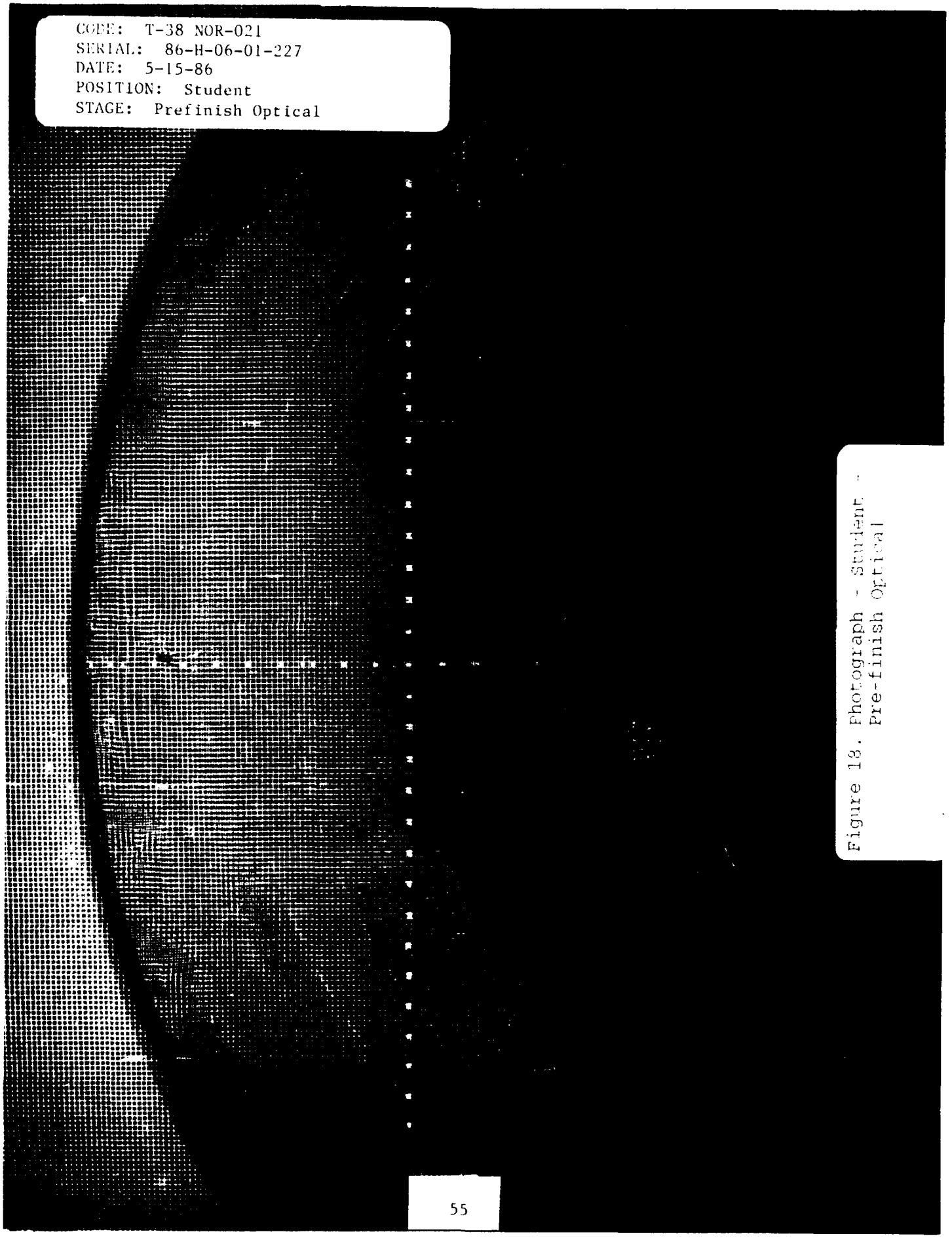


Figure 18. Photograph - Student - Pre-finish Optical

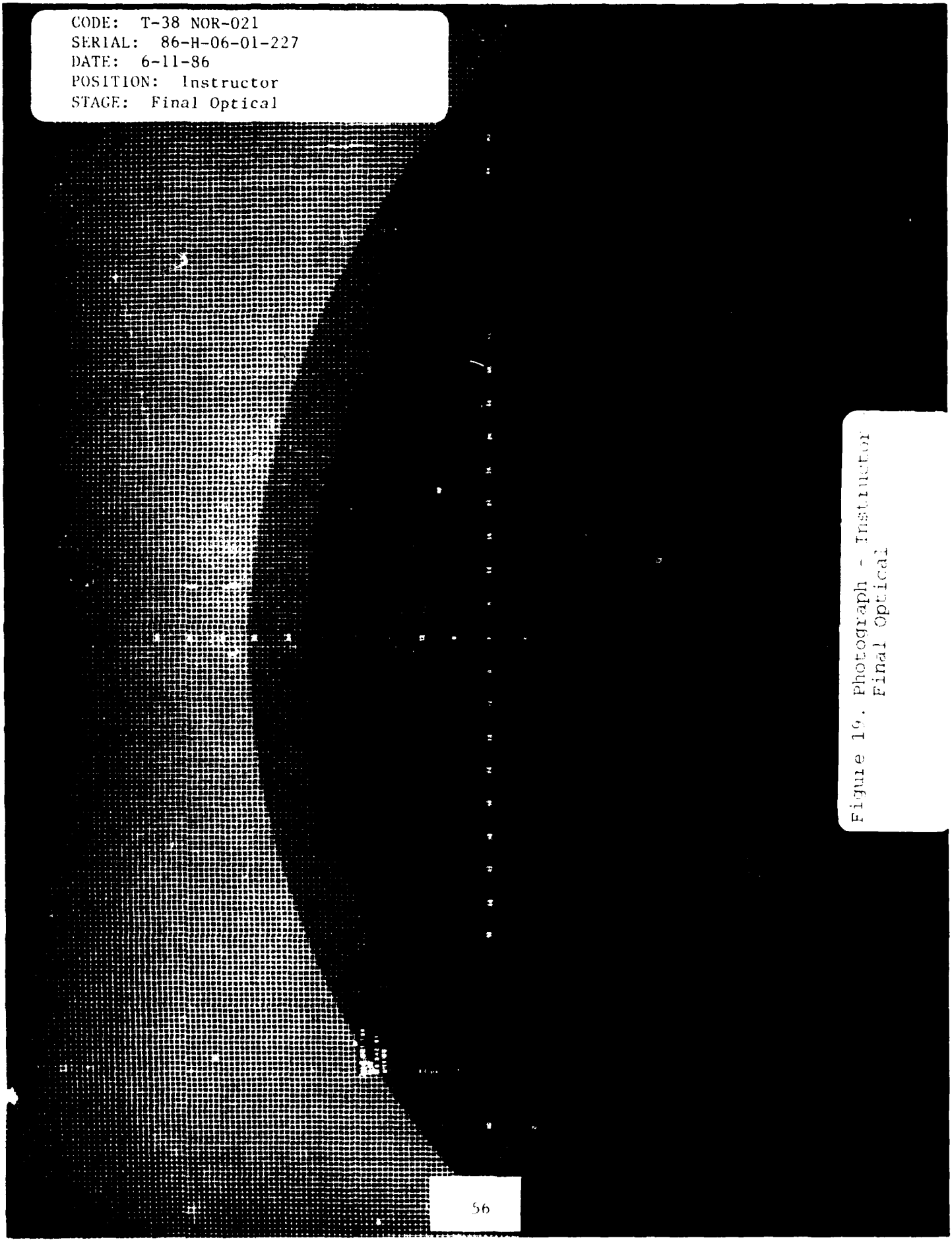


Figure 19. Photograph - Instructor Final Optical

CODE: T-38 NOk=021
SERIAL: 86-H-06-01-227
DATE: 6-11-86
POSITION: Instructor
Single Exposure

CODE: T-38 NOR-021
SERIAL: 86-H-06-15-202
DATE: 5-15-86
POSITION: Instructor
STAGE: Prefinish Optical

Figure 41. Photograph - instructor pre-finish optical

Figure 22. Photograph - Instructor Final Optical

CODE: T-38 NOR-021
SERIAL: 86-H-06-15-202
DATE: 5-15-86
POSITION: Student
STAGE: Final Optical

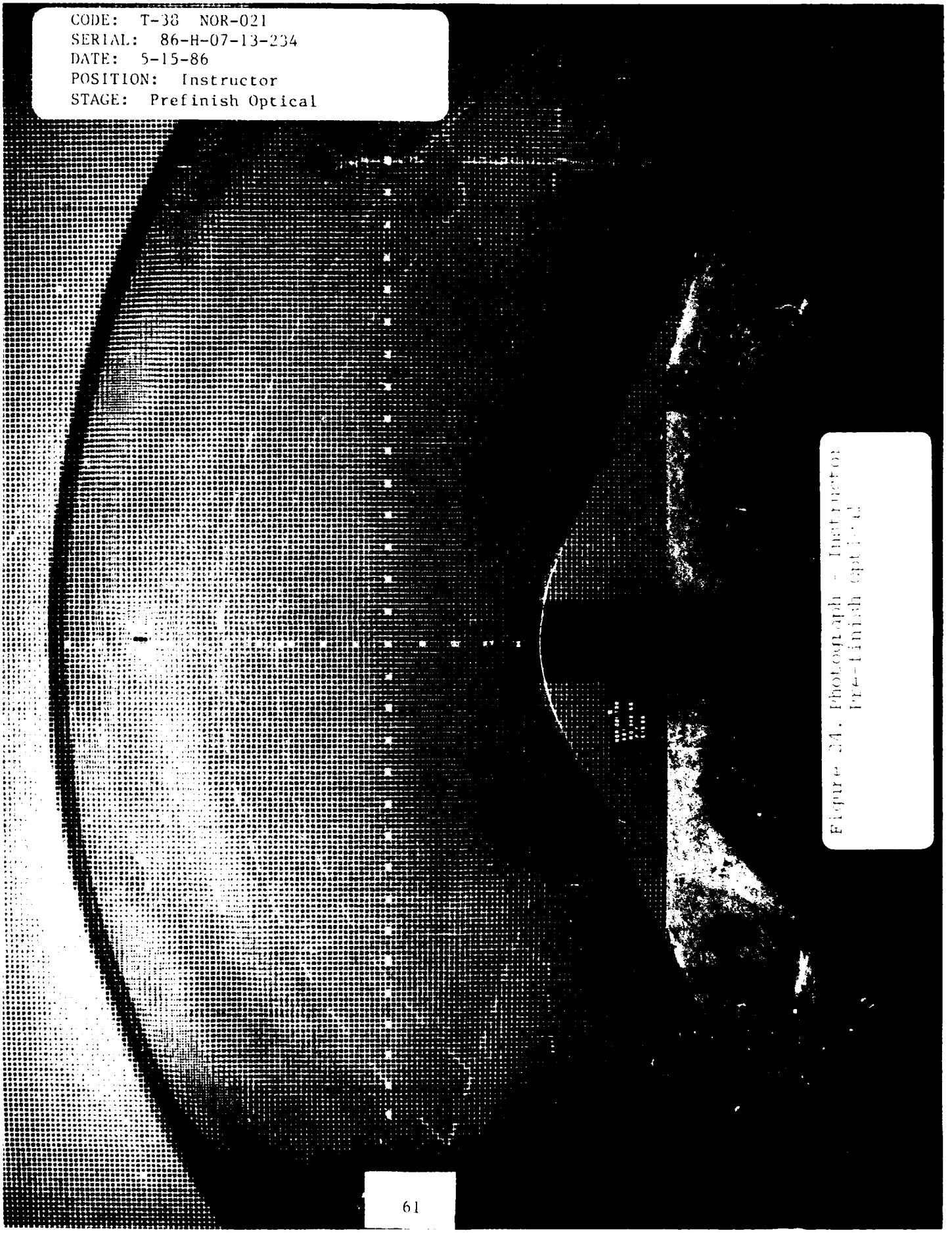


Figure 24. Photograph - Instructor pre-finish optical

CODE: T-38 NOR-021
SERIAL: 86-H-07-13-234
DATE: 7-25-86
POSITION: Instructor
STAGE: Final Optical

Figure 25. Photograph - Instructor
Final Optical

Figure 26. Photograph - Student - Final Optical

Figure 27. Photograph - Instructor - Final Optical

Figure 28. Photograph - Student - Final Optical

CODE: T-38 NOR-021
SERIAL: 86-H-24-032
DATE: 8-26-86
POSITION: Instructor
STAGE: Final Optical

Figure 29. Photograph - Instructor Final Optical

Figure 30. Photograph Student Single Exposure

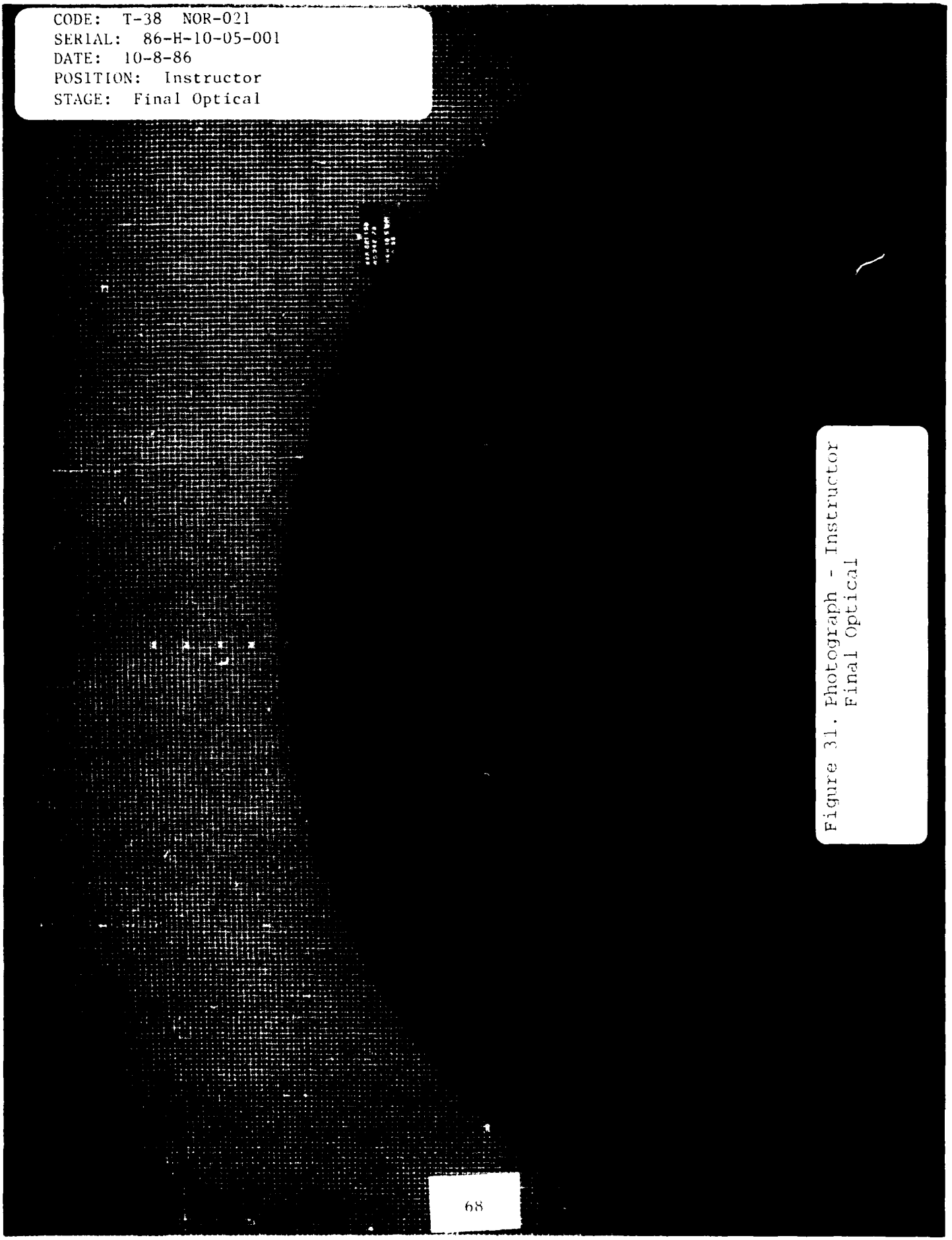


Figure 31. Photograph - Instructor Final Optical

Figure 32. Photograph - Student
Final Optical

9.3.1 Results

Several scratches were noted on PPG 5300 windscreen liner surface. These scratches were located in the right-forward area and about 6-inches from windscreen rear. Project Engineer, Bob Pinnell, was apprised of this finding and had the opportunity to inspect these scratches. They were deemed to be fixable. Scratches were removed with Novus Plastic Polish, using light polishing.

9.4 Distortion

The presence of windscreen distortion was determined by taking photographs, through windscreen, of a string grid board against a black homogeneous background. Photos were taken from the design eye position with the string board position. Windscreen was positioned at its approximate installed angle position.

9.4.1 Results

Examination of windscreen photos, indicated little or no distortion present.

9.5 Multiple Imaging

Multiple imaging was determined by taking photographs through windscreen, from the design eye position, of a 7-inch by 7-inch light-array grid board. Grid board was located approximately 20-feet from design eye position and windscreen was positioned at its approximate installed angle position.

9.5.1 Results

Examination of multiple imaging photo indicated presence of a strong multiple imaging effect in this windscreen. Photos, Figures 33 and 34,

T-38 Multiple Image Photo

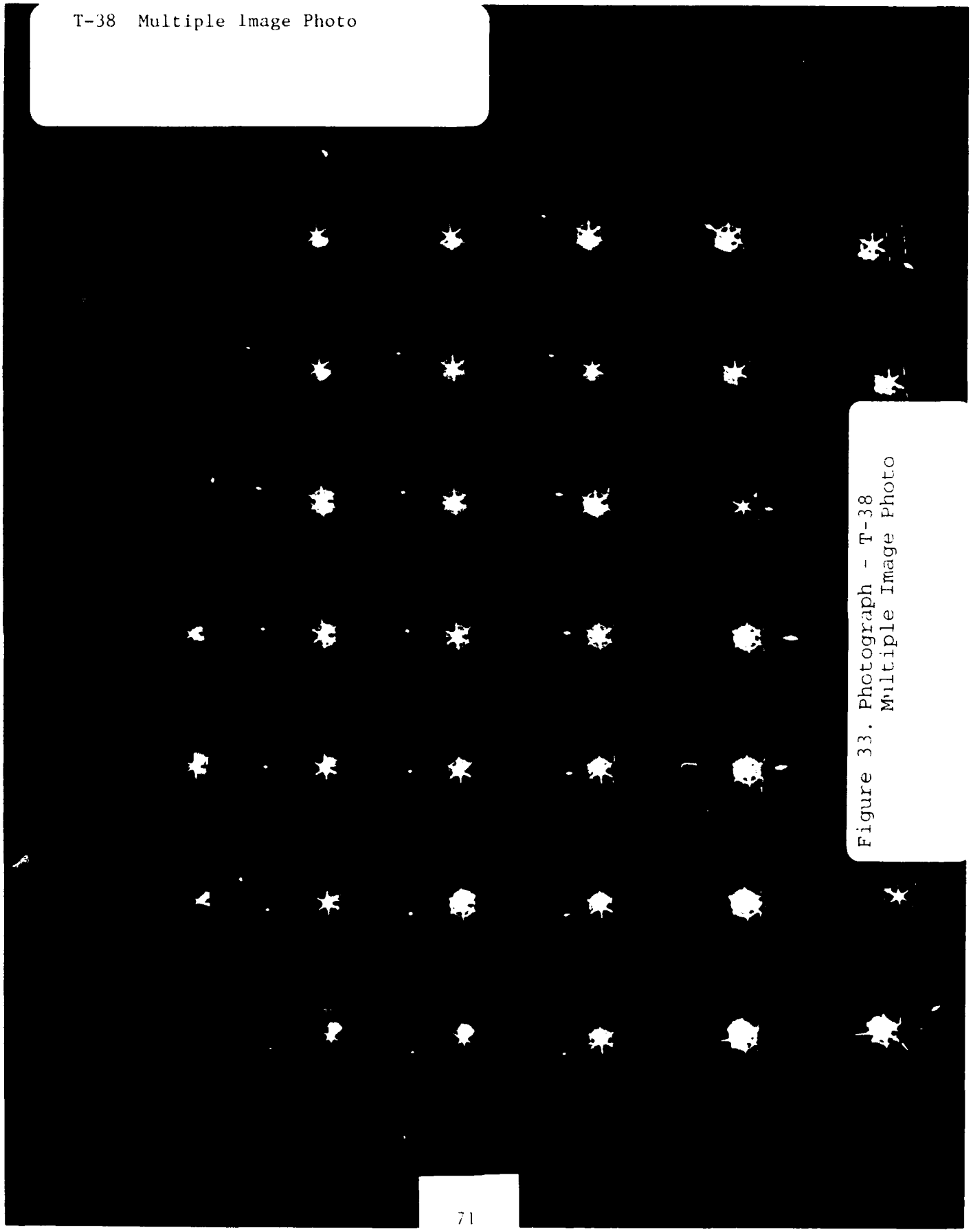


Figure 33. Photograph - T-38
Multiple Image Photo

T-38 Multiple Image Photo

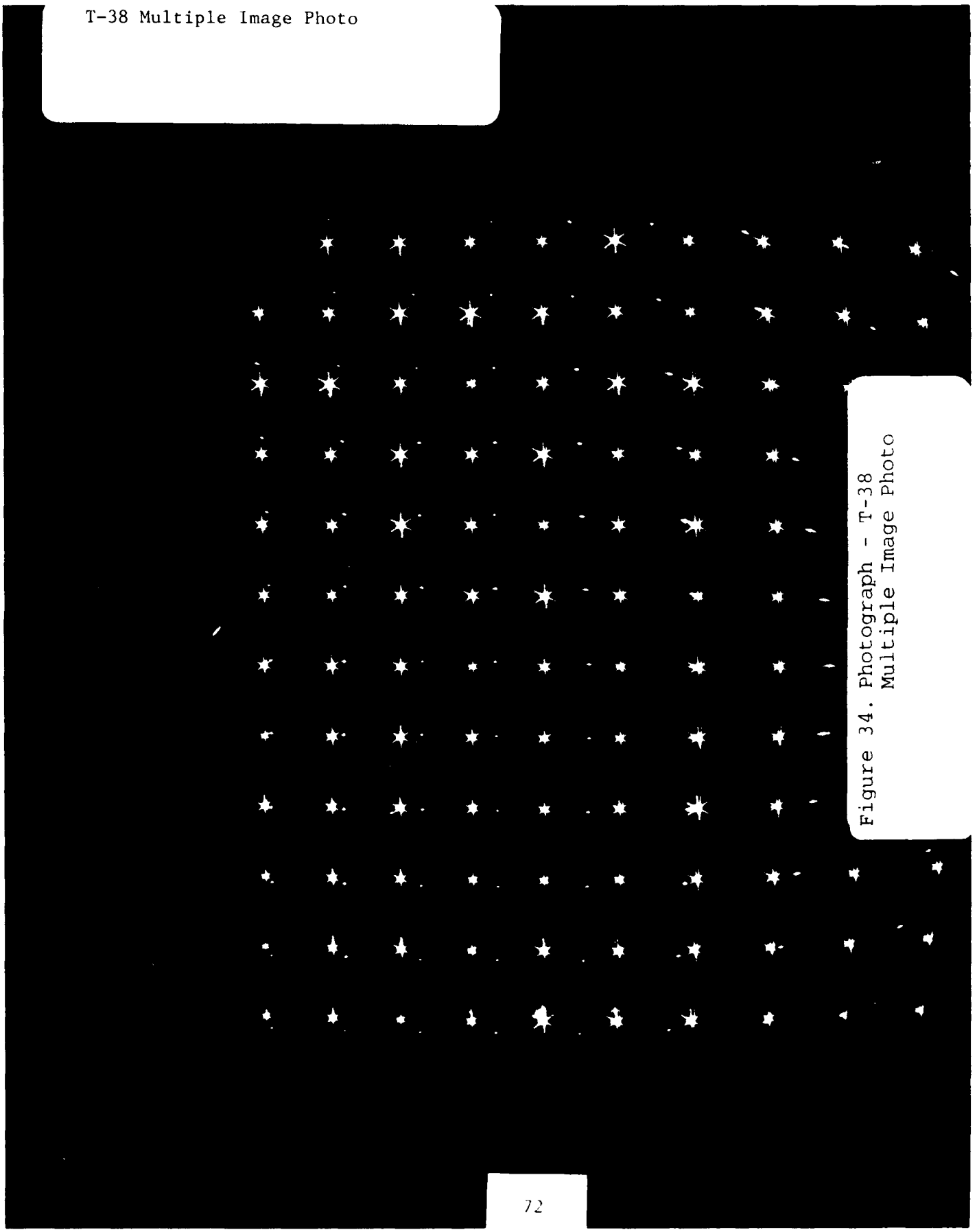


Figure 34. Photograph - T-38
Multiple Image Photo

clearly show the presence of not only intense secondary images, but also the presence of tertiary images.

9.6 Haze

The amount of windscreen haze present was determined by using the backscatter haze meter. Windscreen measurements were made in several areas (right side, center, and left side).

9.6.1 Results

Haze (1.13 percent) was found to be well within specification (3.0 percent).

9.7 Transmissivity

The transmissivity of windscreen was determined by taking readings of a standard light source (Illuminant C) with and without windscreen interposed, using a hand held photometer. Measurement ratio without windscreen, to measurement with windscreen, yields windscreen transmissivity value.

9.7.1 Results

Although somewhat low, (59.3 percent), transmissivity for this windscreen was deemed to be acceptable.

9.8 WPAFB AAMRL/HEF Recommendation

Based on results obtained, this windscreen to be flight acceptable with the following caveat:

Presence of strong multiple imaging effect in this windscreen led AAMRL to suggest that this windscreen be limited to daylight flights only. Multiple imaging may severely degrade visual performance during night flights.

9.9 Discussions Of AAMRL Findings And Test Methods

A meeting was held at WPAFB on October 7, 1989, to discuss AAMRL findings and test methods. On multiple imaging, AAMRL test results had led to AAMRL recommendation that windshield be used for daylight flying only. ATC restriction prohibiting night flying of aircraft, with the OT&E windshields was based on instructor pilot (rear cockpit) inability to land aircraft, due to blockage of viewing area by aft arch reinforcement added to achieve bird impact resistance. Although OT&E postflight evaluations specifically asked for multiple imaging evaluation, relatively few negative ratings were noted. Most of the flights reflect daylight flying, where multiple imaging is not a problem.

There was a minimal number of postflight evaluations from night flying, but these evaluations did not contain enough negative multiple imaging responses to draw any conclusions. Additionally, it was discovered during the meeting that subject windshield was not positioned at correct installation angle during WPAFB AAMRL testing. Since multiple imaging was the only negative test of those performed, it was agreed that the multiple imaging test be rerun at correct position. It was also agreed that AAMRL, multiple imaging test results be compared with AAMRL data for B-1 windshields.

According to AAMRL, a level of acceptance for the B-1 windshield had been loosely established. Considering ATC night flying restriction was not based on multiple imaging, AAMRL performed additional multiple imaging tests at correct installation angle. No written report was ever received by PPG, but verbal word was relayed that multiple imaging was not a problem when windshield was retested at correct installation angle.

AAMRL testing for light transmissivity utilized a technique based on comparison of photometer readings of a light source with and without transparency in the light path, resulted in a transmissivity reading of 59.3 percent. This value was much lower than the values (82 percent to 85 percent) obtained by PPG for the same windshield, utilizing present standard test method (FTM 406, Method 3022). The standard method used by PPG measures the combination of both scattered and direct light in a direction perpendicular to transparency surface.

The AAMRL method measures only direct light through windshield inclined at the installed angle. According to AAMRL the value (59.3 percent) is representative of values obtained for similar transparencies using the same test method. PPG read numerous coupon samples using the standard method with all reading in the 82 percent to 86 percent range, well above the minimum requirement of 80 percent for this windshield. No work was performed using hand held photometer by PPG.

10.0 CANOPY AND WINDSHIELD COVER TESTING

This exercise was performed and documented to determine if the standard T-38 canopy and windshield cover would have an effect on PPG 5300 surface liner. A canopy/windshield cover was obtained from Randolph AFB and sent to PPG Industries, Huntsville, Alabama. The cover was then placed on bird impact testing fuselage. This fuselage was located on a concrete pad adjacent to Impact Facility.

This location permitted the test item to be exposed to all normal environmental conditions occurring between September 22, 1986, and January 20, 1987. See Table 6 for T-38 Canopy Cover Inspection Log, showing dates, time, temperature, observations, and comments. During testing period, cover was secured in place, and remained on the transparencies except for the time when visual examinations occurred.

Table 6. T-38 Canopy Cover Inspection Log

DATE	TIME	TEMPERATURE	OBSERVATIONS AND COMMENTS
22-Sep-86	11:00 AM	82 F	RECEIVED COVER AND PLACED ON FUSELAGE
22-Sep-86	2:30 PM	87 F	NO NOTICEABLE MARK-OFF
23-Sep-86	1:30 PM	88 F	LIGHT MARK-OFF AT SEAM BUTT JOINT--ENTIRELY GONE IN 5 MINUTES
25-Sep-86	11:00 AM	85 F	LIGHT MARK-OFF AT SEAM BUTT JOINT--ENTIRELY GONE IN 5 MINUTES
2-Oct-86	8:00 AM	75 F	LIGHT MARK-OFF AT SEAM BUTT JOINT--ENTIRELY GONE IN 5 MINUTES
8-Oct-86	3:00 PM	88 F	LIGHT MARK-OFF AT SEAM BUTT JOINT--ENTIRELY GONE IN 5 MINUTES
17-Oct-86	10:30 AM	60 F	ALMOST NO MARKING VISIBLE--ENTIRELY GONE IN 10 MINUTES
3-Dec-86	1:00 PM	40 F	LIGHT MARKS AT SEAM BUTT JOINTS--ENTIRELY GONE 10-15 MINUTES
20-Jan-87	1:30 PM	45 F	NO OVERALL MARKING--HEAVIER MARKS AT SEAMS--PROBABLY DUE TO LENGTH OF TIME COVER WAS ON AND LOWER TEMPERATURES

APPENDIX A

BIRD IMPACT TEST REPORTS
T-38 ALTERNATIVE TRANSPARENCIES
MAY 29, THROUGH MAY 31, 1985
INFORMAL REPORT

BIRD IMPACT TEST REPORT
T-38 ALTERNATIVE TRANSPARENCIES
5/29 THROUGH 5/31 1985
INFORMAL REPORT

PPG INDUSTRIES, INC.
AIRCRAFT PRODUCTS DIVISION
TECHNOLOGY DEVELOPMENT GROUP
HUNTSVILLE, ALABAMA

PREPARED BY: H. E. Goodrich

H. E. Goodrich
Senior Development Engineer

6-20-85
Date

TABLE OF CONTENTS

1.0 OBJECTIVE

The objective of this test program was to evaluate the T-38 windshield and edge attachment design as a unit under bird impact and environmental conditions combined. Two windshields were to be impacted with four impacts per windshield as specified in the T-38 Test Plan-Bird Impact document.

2.0 TEST PROCEDURE

The program was designed to impact two test windshields using Table I of the test plan for temperatures, locations and speeds. The first six shots of the table were to be included in the test program. Hot temperature would be generated by a thermal heating blanket system while cold temperatures would be reached using gaseous Liquid Nitrogen as a cooling mechanism. The impact locations were to be as specified on Figure 4 of the Test Plan - Bird Impact.

3.0 TEST RESULTS

Five bird impacts were made on two windshields during the completion of the test program. The first test window (322-52) was impacted at 401.62-knots with a 4.012-pound bird. The impact (shot #156) was made 9-inches forward of the aft arch on the center line of the window after a 15-minute soak period at an outboard surface temperature of approximately 210°F. Just prior to impact the electric heating blanket was removed which caused the actual surface temperature reading at impact to drop to 183.7°F. outboard and 162.6°F. inboard. The impact produced sufficient deflection in the aft arch to allow bird debris to enter the cockpit area and strike the witness plate.

Eight thermocouples were positioned on the windshield for temperature gradient verification. Two of the required three readings were taken 12-inches back from the nose on the center line at a position 3-inches up from the sill, one inboard and the other outboard. The third reading was taken inboard along the center line at a position 10-inches away from the windshield surface. All of the other thermocouples were positioned as shown on the sketch in the data section of the report. The data presented has information headings that are not representative of the actual locations displayed on the sketch.

Shot #157 was made on the same windshield and in the same location but at room temperature. The impact was at 137.2-knots with a bird package weight of 3.996-pounds. A small amount of debris entered the cockpit area on this shot as well.

The third and fourth shots were also made at room temperature on windshield 322-52 but in the sill-corner location as specified in Figure 4 of the Test Plan - Bird Impact. Shot #158 was a 404.6-knot shot with a 4.018-pound bird that did no apparent damage to the structure. The last shot on this window (shot #159) was made at 136.98-knots with a 4.016-pound bird and also produced no apparent additional damage to the windshield system.

Windshield 322-45 was installed for the next sequence of test shooting which consisted of cold and room temperature shots. The first (#160) was made after a cooling soak for 15-minutes at approximately -10°F. outboard surface temperature. The same eight thermocouple locations were recorded that were previously documented for the hot shot. Just prior to impact, the enclosure used to contain the cooling gases was removed and several photographic lamps turned on. The lamps generated enough heat so that the actual test temperatures at impact were 5°F.on the outboard surface and 40°F.on the inboard. The impact was made at 402.35-knots with a 4.002- pound bird and proved to be a catastrophic type failure. A large plug type section of the windshield was blown out in the impact area which was located at a point 9-inches forward of the aft arch on the transparency center line.

DATA RECORDINGS

(1)

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: W.O. 0372-27
SAMPLE IDENTIFICATION CODE: 322-52 CLASSIFICATION:
TEST DATE REQUESTED: 5-29-85 REQUESTED BY: J.W. MYERS
PANEL TYPE: FULL SIZE X 26"x26" BOLTED ___ CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X TEST PLAN T-38
PANEL CROSS SECTION: REF FIG. 1 BIRD IMPACT

5300 LINER
3/8 Poly
.060 112
3/16 Poly
8500 COATING

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES (X) NO ( )
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

REF MEMO W.R. PINNELL MAY 2, 1985

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	180°F	162.6°F
TEMPERATURE OUTBOARD	210°F	183.7°F ★
BIRD WEIGHT (#)	4 lb	4.012#
BIRD SPEED (KNOTS)	400 KNOTS	401.62

AMBIENT TEMP: ___
IMPACT LOCATION: 9" FWD AFT AEEH CL
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: —
REF: FIG 4 T-38 BIRD IMPACT TEST PLAN

REF: T-38 TEST PLAN - BIRD IMPACT

TEST RESULTS: SHOT NO: 156 TEST DATE: 5/29/85 TESTED BY: HEG

WINDSHIELD PASSED. DEFLECTION PERMITTED BIRD TO ENTER "COCKPIT" AND IMPACT WITNESS PLATE.

★ TEST TEMPERATURE DROPPED FROM 212°F TO RECORDED VALUE AFTER BLANKET REMOVED.

PPG WITNESS H Goodrich CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

(2)

TEST PROGRAM: T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO 0372-27
SAMPLE IDENTIFICATION CODE: 322-52 CLASSIFICATION:
TEST DATE REQUESTED: 5-29-85 REQUESTED BY: J. W. MYERS
PANEL TYPE: FULL SIZE X 26" x26" BOLTED CLAMPED OTHER
MOUNTING FRAME: RIGID FLEXIBLE OTHER X
PANEL CROSS SECTION: 5300 LINER
3/8 Poly
.060 112
3/16 Poly
8500 COATING

REF FIG 1 T-38 TEST PLAN - BIRD IMPACT

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES ( ) NO (X)
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	AMBIENT	R.T.
TEMPERATURE OUTBOARD	AMBIENT	R.T.
BIRD WEIGHT (#)	4 lb	3.996#
BIRD SPEED (KNOTS)	130 KNOT	137.2

AMBIENT TEMP:
IMPACT LOCATION: 9" FWD AFT ARCH CL
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: —
→ REF FIG 4 T-38 TEST PLAN - BIRD IMPACT

REF: T-38 TEST PLAN - BIRD IMPACT

TEST RESULTS: SHOT NO: 157 TEST DATE: 5-29-85 TESTED BY: H.E.G.

WINDSHIELD PASSED SECOND IMPACT AT ROOM TEMP. OF 70-80°F. SMALL AMOUNT OF BIRD ENTERED "COCKPIT" AND IMPACTED WITNESS PLATE.

PPG WITNESS CUSTOMER WITNESS

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

3)

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO. 0372-27
SAMPLE IDENTIFICATION CODE: 322-52 CLASSIFICATION:
TEST DATE REQUESTED: 5-29-85 REQUESTED BY: J. W. MYERS
PANEL TYPE: FULL SIZE X 26"x26" BOLTED CLAMPED OTHER
MOUNTING FRAME: RIGID FLEXIBLE OTHER X
PANEL CROSS SECTION: 5300 LINER
3/8 Poly
.060 112
3/16 Poly
8500 COATING

REF: FIG 1 T-38 TEST PLAN - BIRD IMPACT

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES (X) NO ( )
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

REF: MEMO W.R. PINNELL MAY 2, 1985

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	AMBIENT	R.T.
TEMPERATURE OUTBOARD	AMBIENT	R.T.
BIRD WEIGHT (#)	4 lb	4.018#
BIRD SPEED (KNOTS)	400 Knots	404.6

AMBIENT TEMP:
IMPACT LOCATION: Sill - Corner
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: —

REF: FIG 4 T-38 TEST PLAN - BIRD IMPACT

REF: T-38 TEST PLAN - BIRD IMPACT

TEST RESULTS: SHOT NO: 158 TEST DATE: 5-30-85 TESTED BY: H.E.G.

WINDOW PASSED 3RD IMPACT. SILL/CORNER LOCATION PRODUCED NO PENETRATION OR ADDITIONAL DAMAGE.

PPG WITNESS CUSTOMER WITNESS

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WATERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO. 372-27
SAMPLE IDENTIFICATION CODE: 322-52 CLASSIFICATION:
TEST DATE REQUESTED: 5-29-85 REQUESTED BY: J.W. Myers
PANEL TYPE: FULL SIZE X 26"x26" ___ BOLTED ___ CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X
PANEL CROSS SECTION: 5300 Liner
3/8 Poly
.060 112
3/16 Poly
8500 Coating

REF: FIG 1 T-38 TEST PLAN - BIRD IMPACT

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES ( ) NO (X)
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	AMBIENT	R.T.
TEMPERATURE OUTBOARD	AMBIENT	R.T.
BIRD WEIGHT (#)	4 lb	4.016 #
BIRD SPEED (KNOTS)	130 KNOTS	136.98

AMBIENT TEMP: ___
IMPACT LOCATION: Sill-Corner
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: —
→ REF: FIG 4 T-38 TEST PLAN - BIRD IMPACT

REF: T-38 TEST PLAN - BIRD IMPACT

TEST RESULTS: SHOT NO: 159 TEST DATE: 5-30-85 TESTED BY: H.E.G.

WINDOW PASSED 4TH IMPACT. LOW VELOCITY SILL/CORNER IMPACT PRODUCED NO PENETRATION OR ADDITIONAL DAMAGE.

PPG WITNESS ___ CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WATERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: W.O. 372-27
SAMPLE IDENTIFICATION CODE: 322-45 CLASSIFICATION:
TEST DATE REQUESTED: 5-30-85 REQUESTED BY: J.W. MYERS
PANEL TYPE: FULL SIZE X 26"x26" ___ BOLTED ___ CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X
PANEL CROSS SECTION:

REF: F16.1 T-38 TEST PLAN-BIRD IMPACT

6300 LINER
3/8 Poly
.060 112
3/16 Poly
8500 COATING

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES (X) NO ( )
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

REF: MEMO W.R. PINNELL MAY 2, 1985

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	25°F	40°F
TEMPERATURE OUTBOARD	-10°F	5°F *
BIRD WEIGHT (#)	4 lb	4.002#
BIRD SPEED (KNOTS)	400 Knots	402.35

AMBIENT TEMP: ___
IMPACT LOCATION: 9" FWD APT ARCH CL
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: —

REF: FIG.4 T-38 TEST PLAN - BIRD IMPACT

REF: T-38 TEST PLAN - BIRD IMPACT

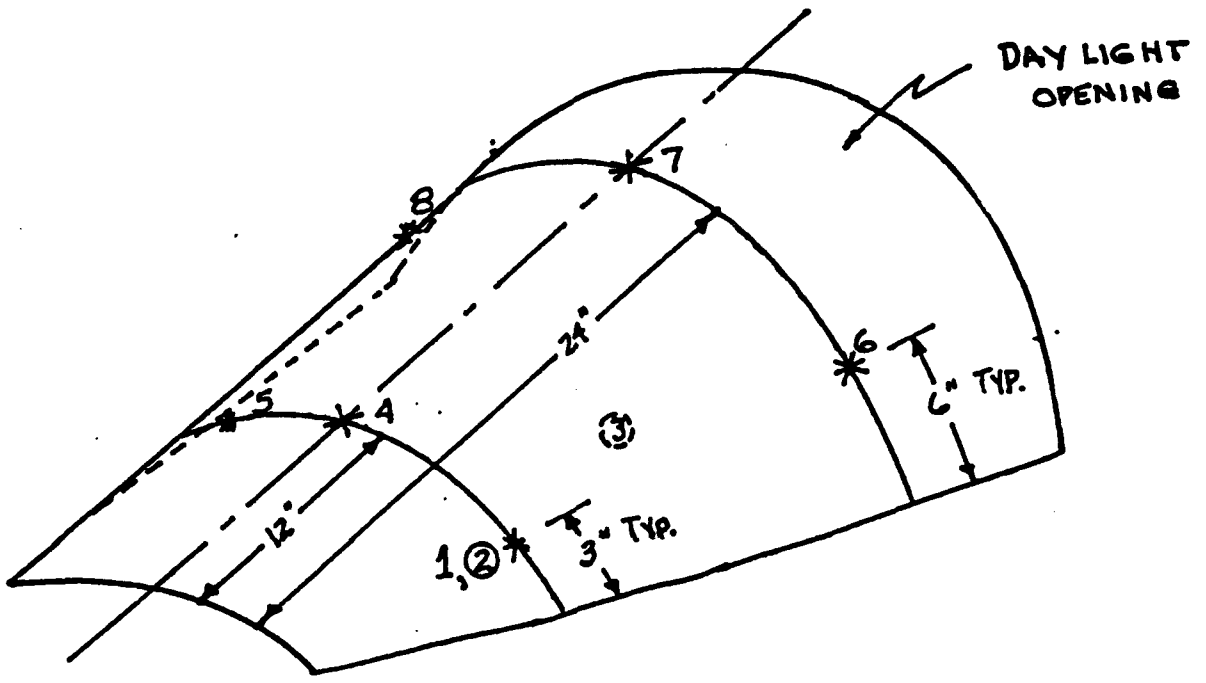
TEST RESULTS: SHOT NO: 160 TEST DATE: 5-31-85 TESTED BY: H.E.G.

WINDSHIELD FAILED CATASTROPHICALLY. IMPACT AREA PLUG BLOWN OUT.

* TEMPERATURE ROSE FROM -53°F TO +5°F WHEN WINDOW EXPOSED TO CAMERA LIGHTING JUST PRIOR TO IMPACT.

PPG WITNESS ___ CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH



○ INBOARD T/C

THERMOCOUPLE LOCATIONS

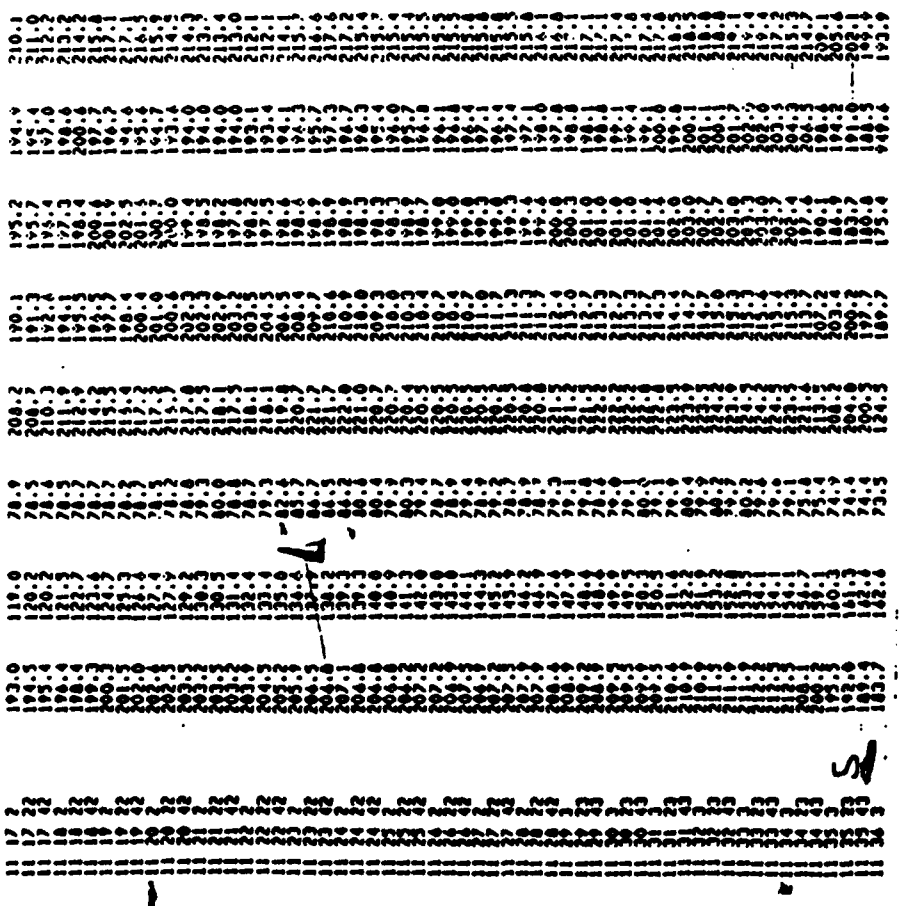
TEST STARTED 05/29/85 10:54:38

THB TEST PANEL S/N IS 322-45

THERMAL CYCLE STRESS TEST FOR T-38 STUDENT WINDSHIELD

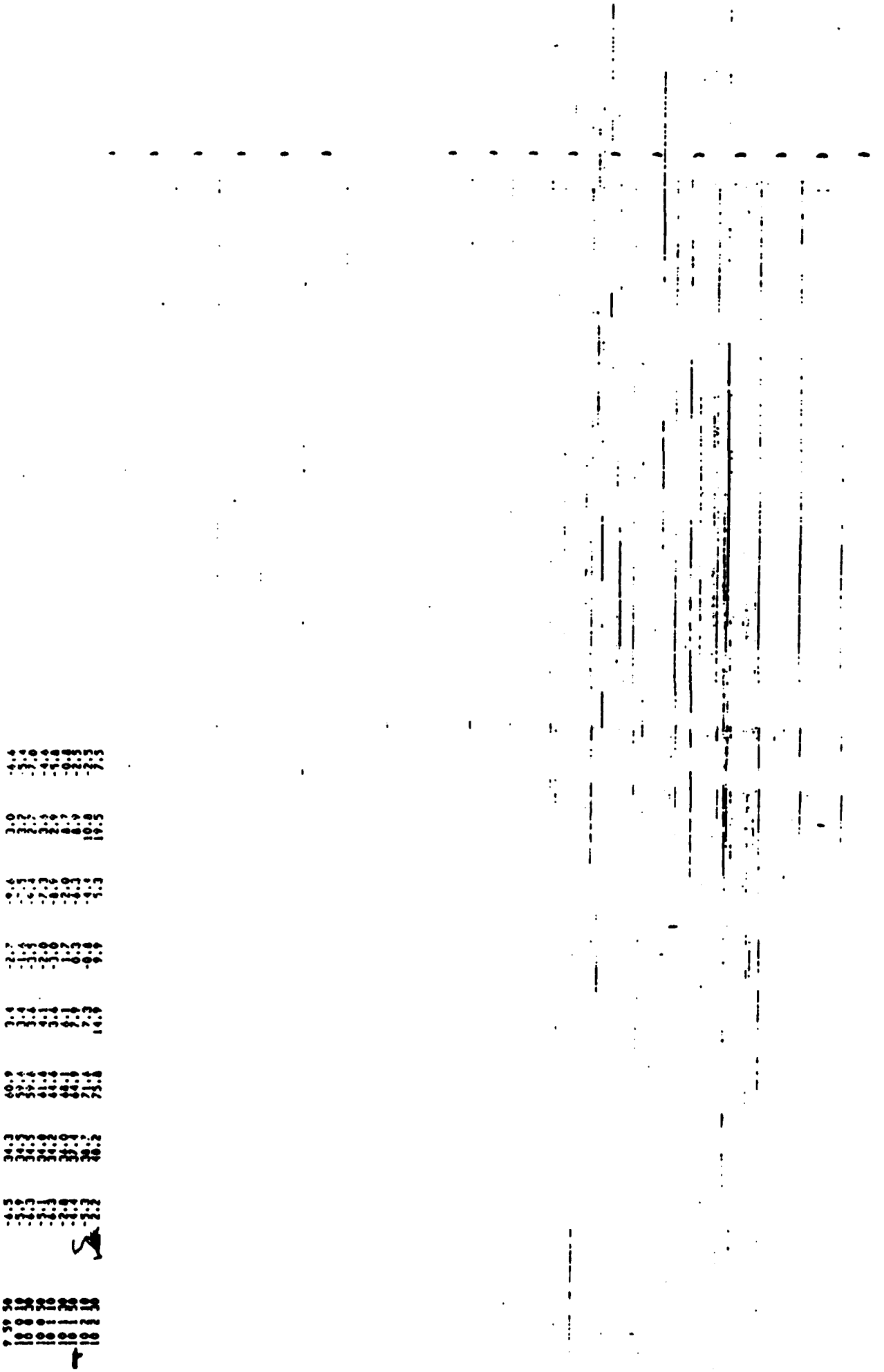
T/C #1 IS I.B. SURFACE TEMPERATURE
T/C #2 IS O.B. SURFACE TEMPERATURE
T/C #3 IS FRAME TEMPERATURE
T/C #4 IS OVEN TEMPERATURE
T/C #5 IS AMBIENT ROOM TEMPERATURE

	TIME	1 DEG.F.	2 DEG.F.	3 DEG.F.	4 DEG.F.	5 DEG.F.	6 DEG.F.	7 DEG.F.	8 DEG.F.
10	54 42	79.3	80.5	80.4	85.2	89.4	80.2	84.0	93.3
10	55 2	79.9	80.2	78.5	85.5	89.8	80.7	85.8	93.3
10	55 22	80.4	80.2	79.4	85.8	90.5	80.2	87.2	93.6
10	55 42	80.5	80.5	78.7	86.7	91.3	81.5	88.1	94.4
10	56 2	81.5	80.7	77.9	88.0	92.3	81.9	90.0	95.7
10	56 22	82.4	80.7	79.4	89.1	94.1	82.4	91.6	96.2
10	56 42	83.9	81.1	79.0	91.1	95.2	83.6	93.7	97.5
10	57 2	84.3	80.9	78.2	91.8	96.4	84.2	94.9	98.0
10	57 22	85.8	80.7	78.7	93.4	98.2	85.5	97.2	99.2
10	57 42	87.3	81.0	79.9	94.9	99.5	87.0	98.4	100.5
10	58 2	89.0	81.2	79.9	97.2	101.2	88.0	100.5	101.6
10	58 22	91.0	81.2	78.5	98.9	103.0	90.1	102.3	102.5
10	58 42	94.9	80.7	79.2	101.5	104.6	91.9	104.6	103.4
10	59 2	93.8	81.2	79.4	104.1	104.1	93.3	105.9	104.1
10	59 22	94.1	81.5	79.2	107.1	108.2	94.9	108.2	105.7
10	59 42	94.4	81.7	79.2	109.8	108.9	96.4	109.9	106.9
11	0 2	94.9	81.9	78.1	111.8	110.2	97.5	112.1	107.9
11	0 22	95.4	82.0	78.9	114.2	111.8	97.9	113.4	109.3
11	0 42	96.5	82.2	78.2	115.7	111.5	98.2	115.4	110.3
11	1 2	97.2	82.4	78.4	117.8	112.1	98.9	116.5	111.4
11	1 22	97.9	83.0	78.7	119.4	114.2	100.0	118.7	112.8
11	1 42	99.3	83.2	79.0	121.4	114.7	101.5	120.0	114.1
11	2 2	101.0	83.2	79.5	123.7	116.0	102.0	121.6	115.1
11	2 22	101.8	83.5	79.7	125.7	117.4	103.1	123.1	116.2
11	2 42	102.8	83.7	78.2	127.1	119.1	104.1	124.5	117.2
11	3 2	103.9	84.3	79.2	129.1	132.1	105.4	126.0	118.5
11	3 22	104.2	84.9	79.8	131.3	133.1	106.6	127.0	119.8
11	3 42	110.3	85.0	79.4	132.5	136.0	108.0	128.6	121.1
11	4 2	113.4	85.9	80.6	133.4	140.4	108.4	129.6	123.7
11	4 22	115.4	85.7	80.3	134.8	142.6	109.4	131.6	124.9
11	4 42	117.2	86.5	79.2	135.7	143.8	110.5	131.7	126.6
11	5 2	119.2	86.9	79.1	137.1	145.8	111.9	134.2	128.2
11	5 22	138.5	87.2	78.5	138.6	147.7	112.6	134.3	129.1
11	5 42	144.3	88.4	80.0	140.3	150.0	114.0	136.3	130.9
11	6 2	144.7	88.6	80.4	141.2	151.2	114.7	137.3	132.5
11	6 22	149.4	88.6	80.7	142.8	152.8	115.6	138.3	133.3
11	6 42	152.0	89.9	81.1	145.2	155.5	140.7	139.7	134.8
11	7 2	153.6	90.9	81.6	146.5	156.5	150.3	142.6	136.9
11	7 22	155.5	91.7	82.0	147.8	158.1	161.9	143.9	138.7
11	7 42	155.8	92.4	82.0	149.1	158.7	165.8	147.4	163.5
11	8 2	156.1	93.0	82.0	157.7	158.1	165.8	149.4	165.3
11	8 22	159.0	93.9	80.8	171.5	159.1	165.8	154.2	189.4
11	8 42	159.4	94.3	80.0	175.2	159.0	167.7	156.5	190.7
11	9 2	160.0	95.3	79.8	177.6	160.0	168.7	158.9	192.3
11	9 22	161.4	96.7	80.5	178.7	159.6	170.3	161.9	192.9
11	9 42	163.2	97.8	81.1	180.5	159.0	171.2	163.1	194.2
11	10 2	163.8	98.6	82.0	182.4	161.3	172.8	164.1	194.1
11	10 22	167.1	99.2	82.0	183.0	162.0	173.5	167.1	194.1
11	10 42	167.3	100.7	79.4	183.0	163.0	174.1	170.5	195.1
11	11 2	166.7	101.7	78.4	183.9	163.9	174.1	172.2	195.8
11	11 22	170.0	102.5	80.2	183.9	164.4	174.1	173.6	196.8
11	11 42	171.4	103.2	79.2	180.2	164.4	174.1	175.2	197.8
11	12 2	172.5	104.1	79.2	190.1	167.8	174.3	176.1	198.7
11	12 22	174.1	104.8	78.8	191.4	169.1	174.0	178.7	199.0
11	12 42	175.8	106.4	79.1	193.0	170.7	180.9	179.7	200.0
11	13 2	177.4	107.5	78.4	194.3	172.2	181.2	181.2	200.7
11	13 22	179.1	108.5	79.0	194.3	174.0	182.4	182.4	202.4
11	13 42	180.4	109.4	79.2	194.9	175.9	183.9	185.3	202.6
11	14 2	182.3	110.5	79.6	196.2	176.8	184.8	185.8	203.6
11	14 22	183.2	110.5	79.2	199.4	178.1	185.8	184.4	203.3
11	14 42	184.2	112.1	80.0	200.4	179.7	186.1	186.4	202.6
11	15 2	185.5	112.9	78.9	201.0	181.3	187.0	187.7	203.5
11	15 22	186.4	113.9	79.0	202.3	182.9	188.3	187.4	203.9
11	15 42	188.0	114.7	78.4	203.6	183.9	189.6	189.3	205.2
11	16 2	190.0	115.8	79.3	205.3	185.9	191.2	190.3	206.8
11	16 22	191.0	117.4	79.1	205.9	187.5	192.2	192.9	207.3
11	16 42	192.2	117.9	79.3	207.2	188.7	193.5	193.2	209.1

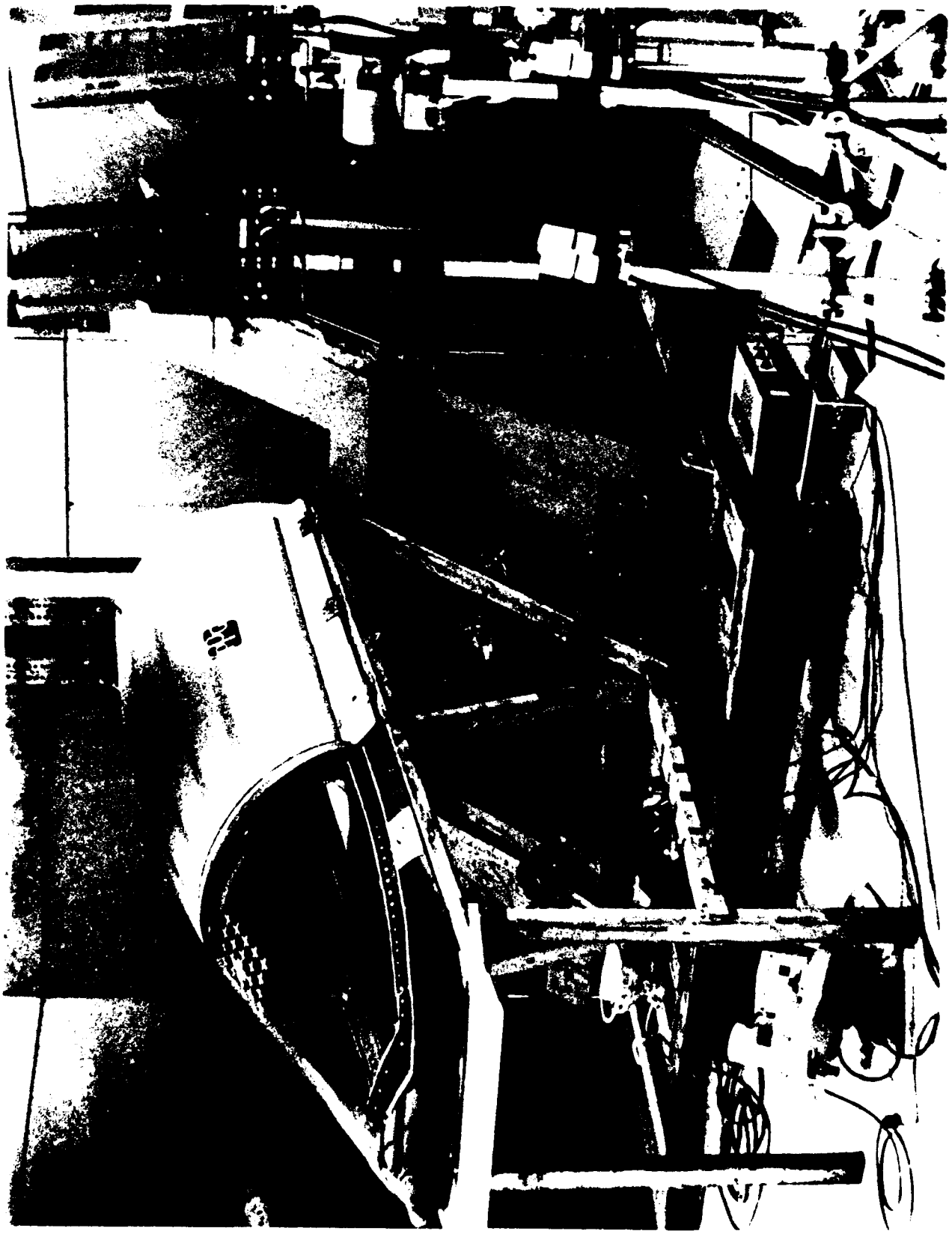


TEST STARTED 05/31/85 09:34:08

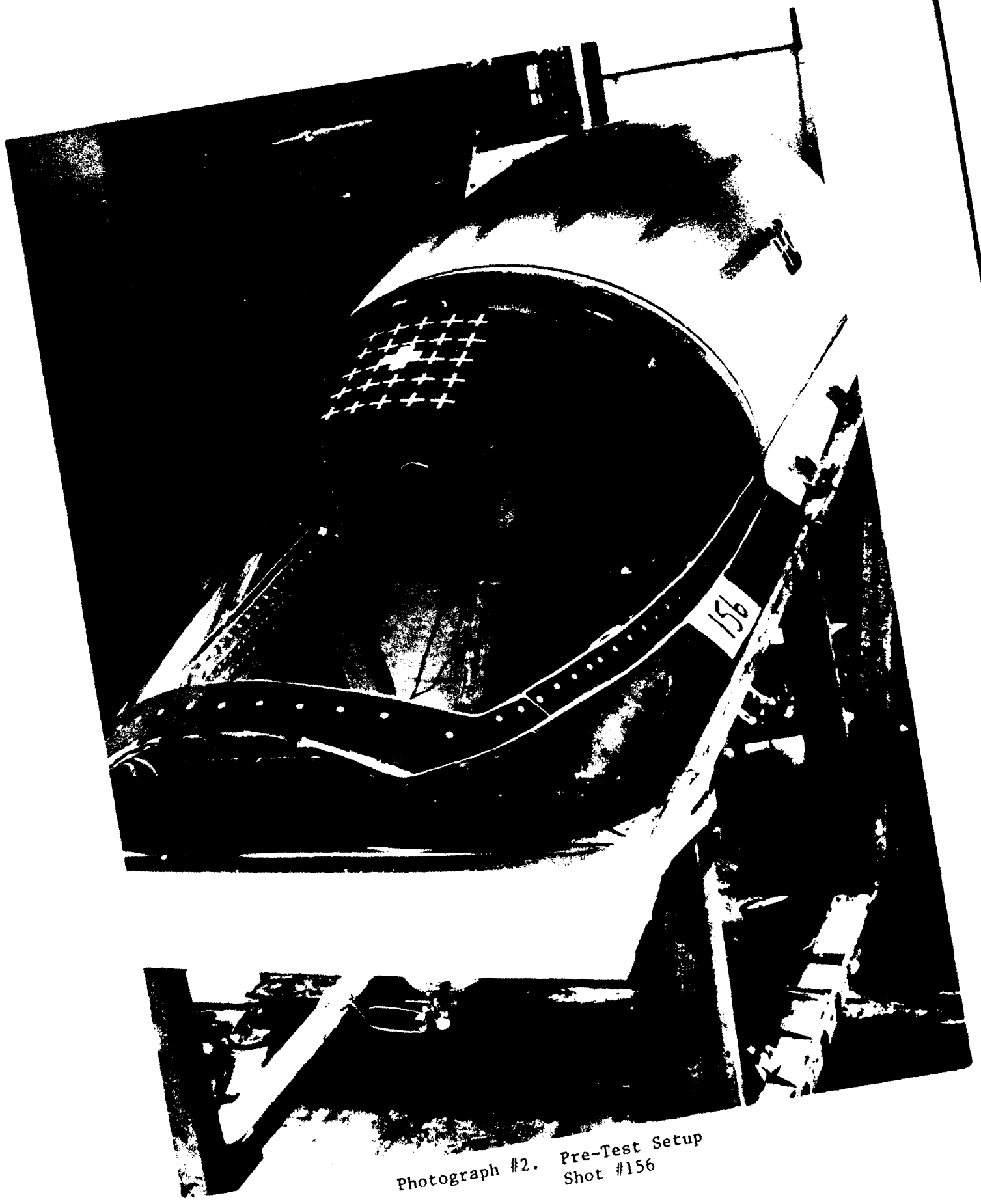
TIME	1 DEG.F.	2 DEG.F.	3 DEG.F.	4 DEG.F.	5 DEG.F.	6 DEG.F.	7 DEG.F.	8 DEG.F.
9 34 10	78.4	78.3	77.9	78.3	77.6	82.3	78.4	77.9
9 34 30	78.6	78.1	77.8	78.3	76.5	81.8	78.4	78.3
9 34 50	78.4	79.1	77.9	78.3	78.1	81.1	78.9	77.6
9 35 10	78.9	77.6	78.1	78.4	78.1	80.9	78.3	77.9
9 35 30	78.8	78.3	78.3	78.7	79.3	81.6	78.9	79.3
9 35 50	78.4	78.4	75.3	78.4	77.9	80.4	78.4	77.8
9 36 10	79.0	78.9	78.4	78.7	79.0	80.[illegible]	78.7	78.7
9 36 30	78.6	78.4	78.6	78.3	78.1	90.3	79.9	77.8
9 36 50	78.6	78.8	77.9	78.3	78.4	80.1	78.4	77.8
9 37 10	78.9	78.4	77.9	78.1	78.4	79.8	78.6	77.9
9 37 30	78.5	78.7	78.2	78.5	78.2	78.9	78.4	77.7
9 37 50	65.5	78.1	64.0	69.0	64.3	62.6	68.8	63.8
9 38 10	59.2	78.4	62.9	64.1	61.4	55.9	64.1	57.7
9 38 30	53.9	77.6	61.1	59.5	55.9	51.2	59.5	51.9
9 38 50	50.4	77.6	63.8	56.1	52.9	47.7	56.8	49.2
9 39 10	46.9	77.8	62.0	53.6	49.6	44.5	54.3	45.4
9 39 30	43.8	77.1	59.8	50.9	46.9	41.5	51.7	42.7
9 39 50	41.8	76.8	60.3	48.5	45.5	40.3	49.9	41.3
9 40 10	41.6	76.4	59.1	47.9	44.5	39.3	49.1	40.6
9 40 30	40.5	76.5	64.0	46.5	43.3	38.9	47.7	39.8
9 40 50	40.1	76.6	60.6	46.0	42.2	38.4	46.8	38.9
9 41 10	37.9	76.0	60.8	44.0	39.9	36.1	45.5	37.1
9 41 30	35.6	75.1	57.8	42.3	38.6	33.2	43.0	34.2
9 41 50	27.9	74.8	55.4	38.1	31.7	24.2	37.1	24.2
9 42 10	23.1	74.3	54.8	32.9	26.9	20.4	33.2	21.6
9 42 30	18.7	73.5	54.3	29.3	23.7	15.8	30.0	17.2
9 42 50	14.9	72.6	58.3	24.6	20.4	12.2	27.1	14.6
9 43 10	11.9	71.6	56.4	24.3	17.5	9.5	24.0	11.9
9 43 30	9.8	71.0	52.2	21.6	13.1	6.2	21.8	8.6
9 43 50	6.0	70.6	52.2	19.6	13.1	2.6	19.4	5.2
9 44 10	3.4	69.3	59.3	17.5	11.3	0.7	17.9	4.3
9 44 30	1.9	68.8	53.9	14.5	10.5	-1.1	14.7	3.4
9 44 50	0.3	67.6	51.4	15.4	9.5	-1.9	14.8	2.8
9 45 10	-0.7	66.6	52.1	14.4	8.3	-3.7	13.9	0.5
9 45 30	-2.6	66.1	52.4	12.9	6.7	-5.7	11.9	-0.7
9 45 50	-4.3	64.6	52.1	11.5	4.5	-6.9	10.3	-3.5
9 46 10	-6.4	63.3	51.9	10.9	3.3	-9.8	8.6	-4.3
9 46 30	-8.2	62.3	48.3	8.2	1.9	-12.0	4.7	-5.4
9 46 50	-12.6	60.8	51.7	4.7	-1.9	-13.7	5.7	-7.6
9 47 10	-12.6	60.3	50.4	3.5	-1.4	-14.5	4.4	-9.0
9 47 30	-10.2	59.7	52.8	2.8	9.3	-11.5	3.9	-4.9
9 47 50	8.2	57.8	56.9	12.2	9.8	-1.1	11.3	3.7
9 48 10	8.3	56.4	58.3	11.8	6.7	-2.6	10.3	1.3
9 48 30	6.3	55.4	58.8	11.2	6.5	-1.9	10.5	1.2
9 48 50	-0.7	53.8	50.1	10.8	4.8	-2.1	9.6	0.5
9 49 10	0.7	52.6	54.4	10.8	5.0	-6.9	5.3	0.7
9 49 30	8.3	51.7	50.9	9.8	3.9	-1.6	8.8	-0.2
9 49 50	6.3	50.6	50.4	10.5	3.6	-1.6	8.6	-0.9
9 50 10	6.7	49.7	57.9	13.8	11.5	7.6	14.4	8.4
9 50 30	10.7	49.6	54.3	17.9	14.6	8.6	16.1	11.0
9 50 50	9.7	48.3	53.3	14.1	8.6	2.7	13.4	4.6
9 51 10	6.4	47.5	53.1	14.8	10.1	3.3	13.2	5.5
9 51 30	7.6	46.7	53.8	15.3	10.8	4.8	14.6	7.2
9 51 50	12.8	46.2	54.4	17.5	15.1	11.3	18.2	12.7
9 52 10	6.3	44.9	53.3	14.2	8.7	2.6	17.4	4.3
9 52 30	10.9	44.6	53.7	17.2	14.5	10.7	17.2	11.8
9 52 50	4.9	43.7	50.3	14.9	8.3	2.8	13.0	4.9
9 53 10	5.9	43.2	50.3	13.8	8.3	3.5	12.8	5.2
9 53 30	5.7	42.7	48.3	13.3	7.3	2.4	12.1	4.2
9 53 50	4.7	42.7	49.0	12.4	6.8	1.8	11.6	3.3
9 54 10	3.9	42.8	48.3	11.1	3.3	-0.6	10.5	1.9
9 54 30	-1.3	41.9	46.9	9.0	0.7	-3.1	2.6	-2.5
9 54 50	-7.6	41.3	47.4	4.2	-4.4	-10.4	3.2	-7.1
9 55 10	-5.2	41.8	46.8	4.2	-3.4	-10.7	3.2	-7.9
9 55 30	-9.3	40.9	51.8	4.7	-2.9	-8.1	4.9	-4.2
9 55 50	-9.8	40.2	49.5	4.0	-4.4	-10.8	1.9	-8.6
9 56 10	-9.2	38.8	40.8	4.5	-3.7	-8.9	3.3	-5.9
9 56 30	-9.7	38.5	40.5	4.0	-4.1	-9.1	2.5	-5.9
9 56 50	-9.3	39.2	38.9	4.8	-2.9	-9.0	3.0	-3.1
9 57 10	-9.2	37.5	40.9	4.2	-3.8	-8.8	3.3	-6.9
9 57 30	-7.2	37.1	53.3	4.2	-3.9	-10.0	2.2	-7.4
9 57 50	-6.2	36.6	51.3	4.4	-2.7	-9.9	3.2	-6.2
9 58 10	-7.7	36.1	49.3	3.5	-4.1	-10.4	3.1	-7.9
9 58 30	-5.9	35.5	47.3	4.1	-2.3	-9.1	3.6	-5.1
9 58 50	-4.3	35.8	44.7	3.7	-1.9	-7.2	3.0	-4.3
9 59 10	-8.8	34.7	50.7	2.9	-4.4	-10.5	2.5	-8.0
9 59 30	-7.0	34.0	51.4	3.2	-3.0	-7.9	2.9	-6.3



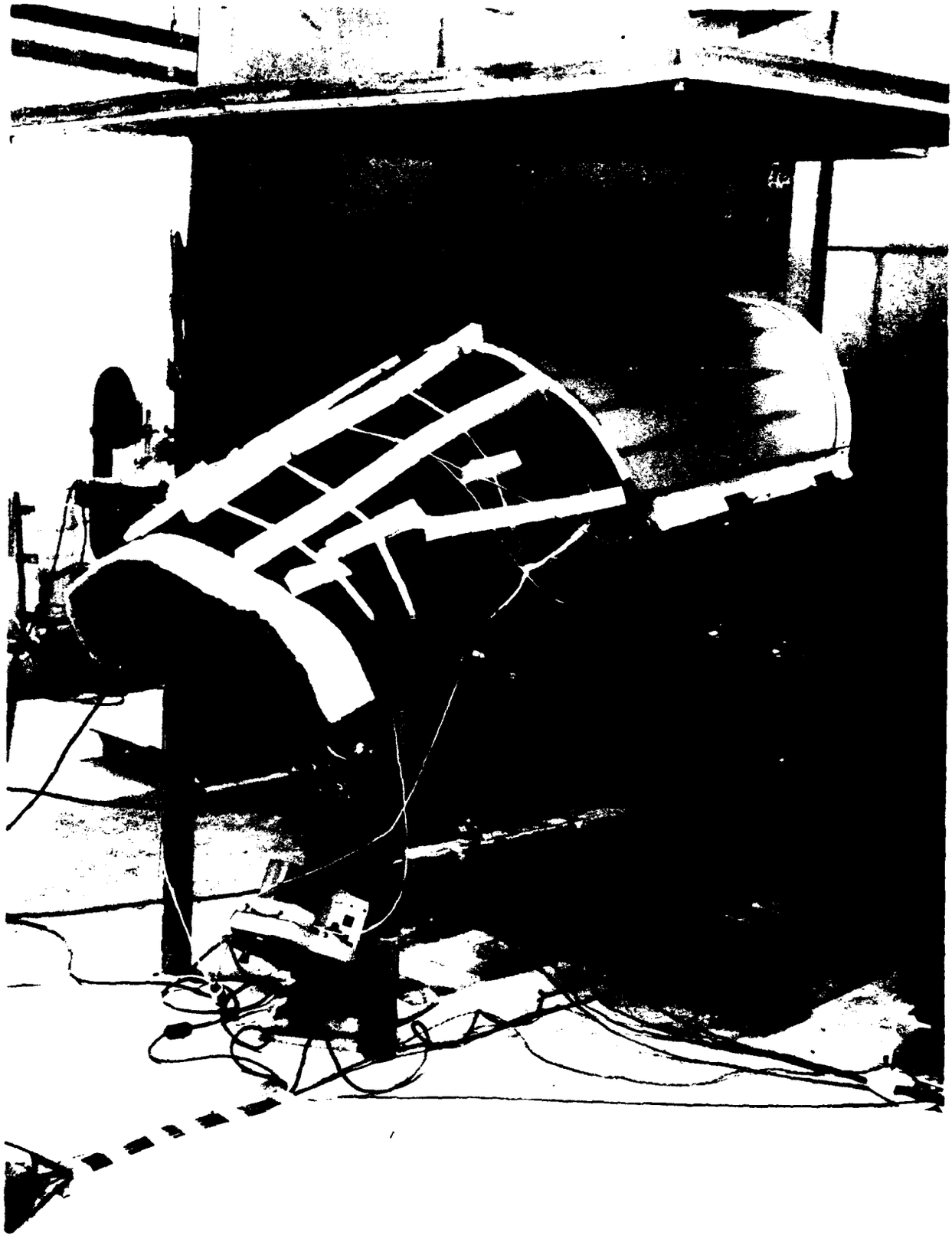
PHOTOGRAPHS



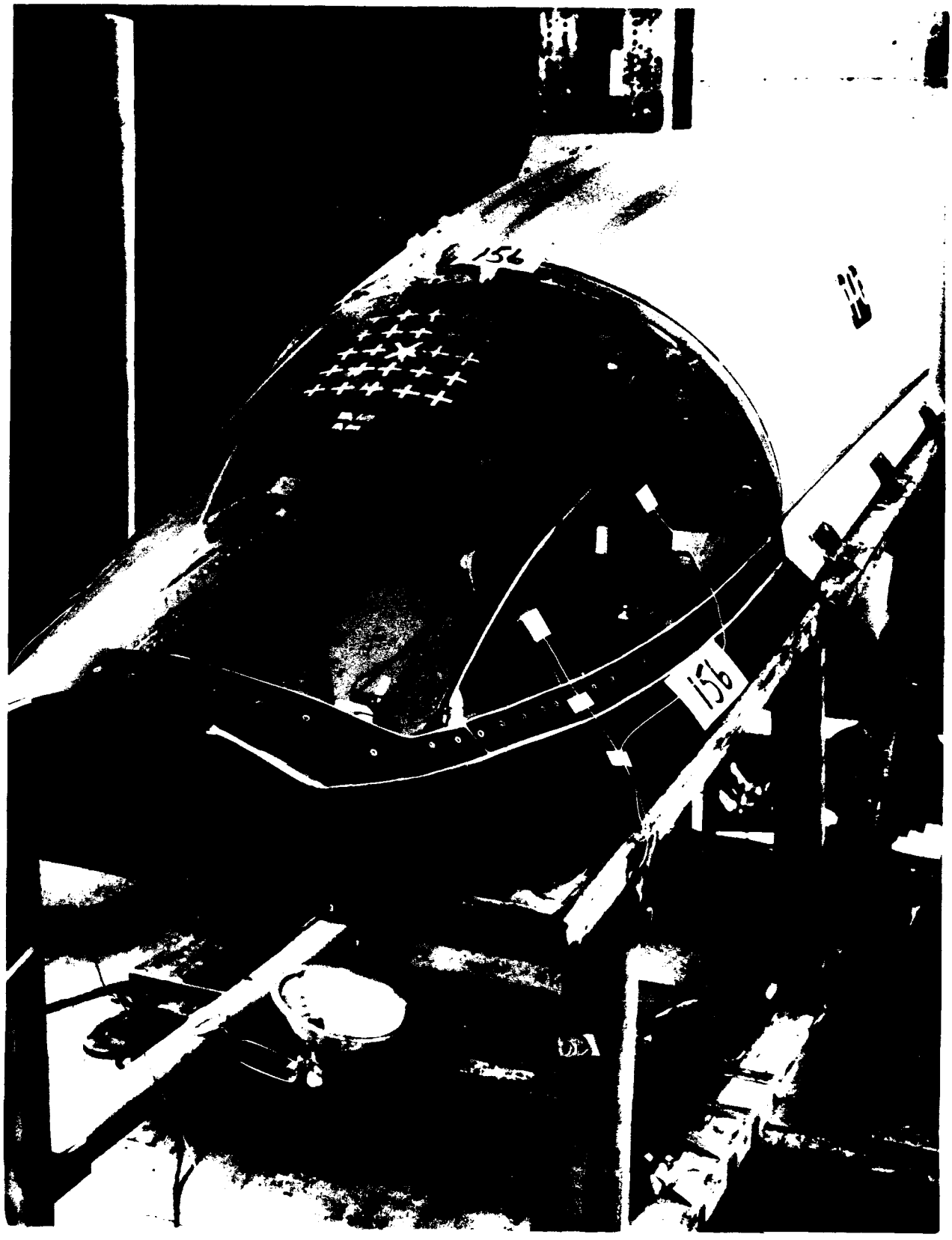
Photograph #1. Overall Pre-Test Setup
Shot #156



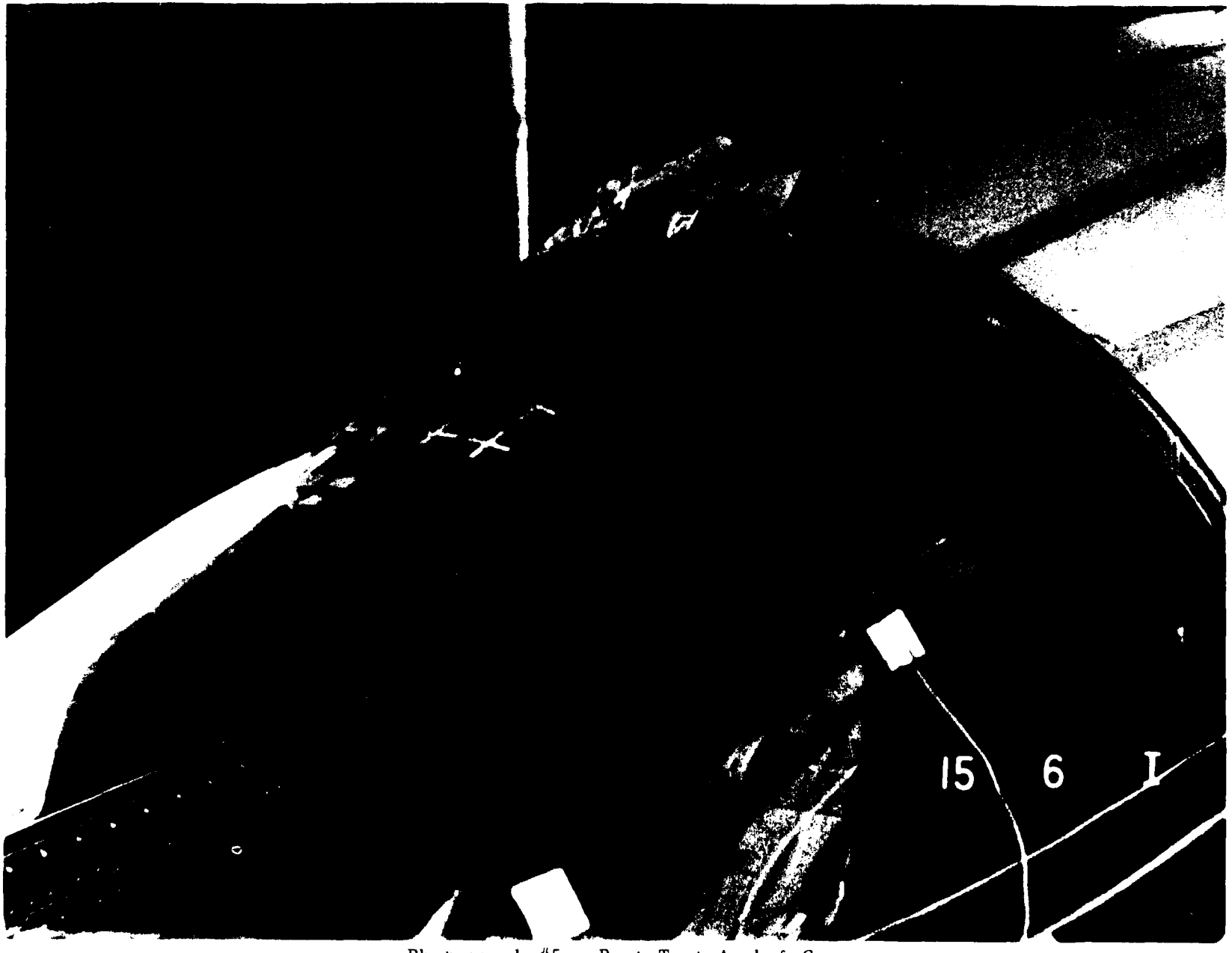
Photograph #2. Pre-Test Setup
Shot #156



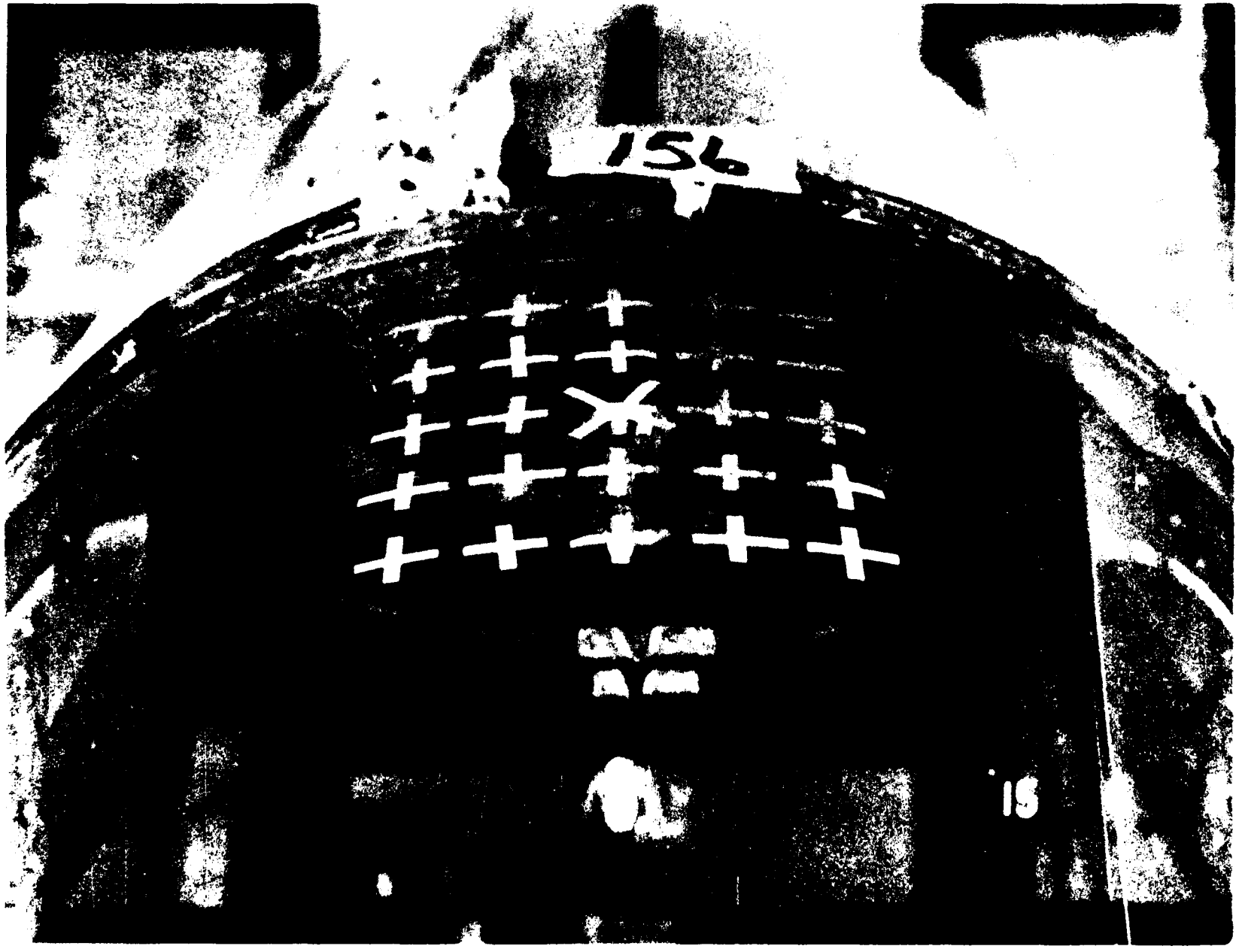
Photograph #3. Heat Blanket Pre-Test
Setup Shot #156



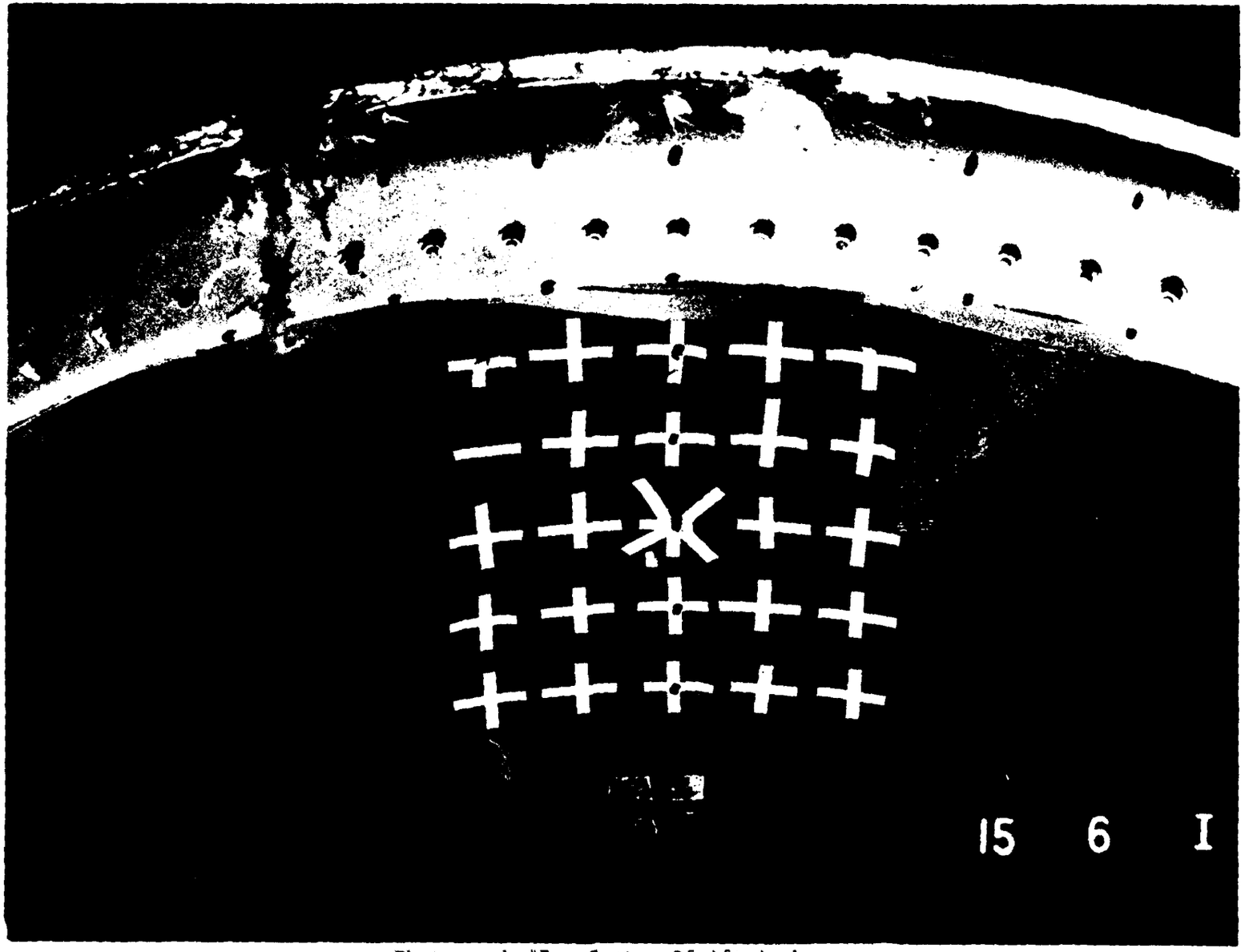
Photograph #4. Post-Test Results
Shot #156



Photograph #5. Post-Test Arch & Canopy
Shot #156

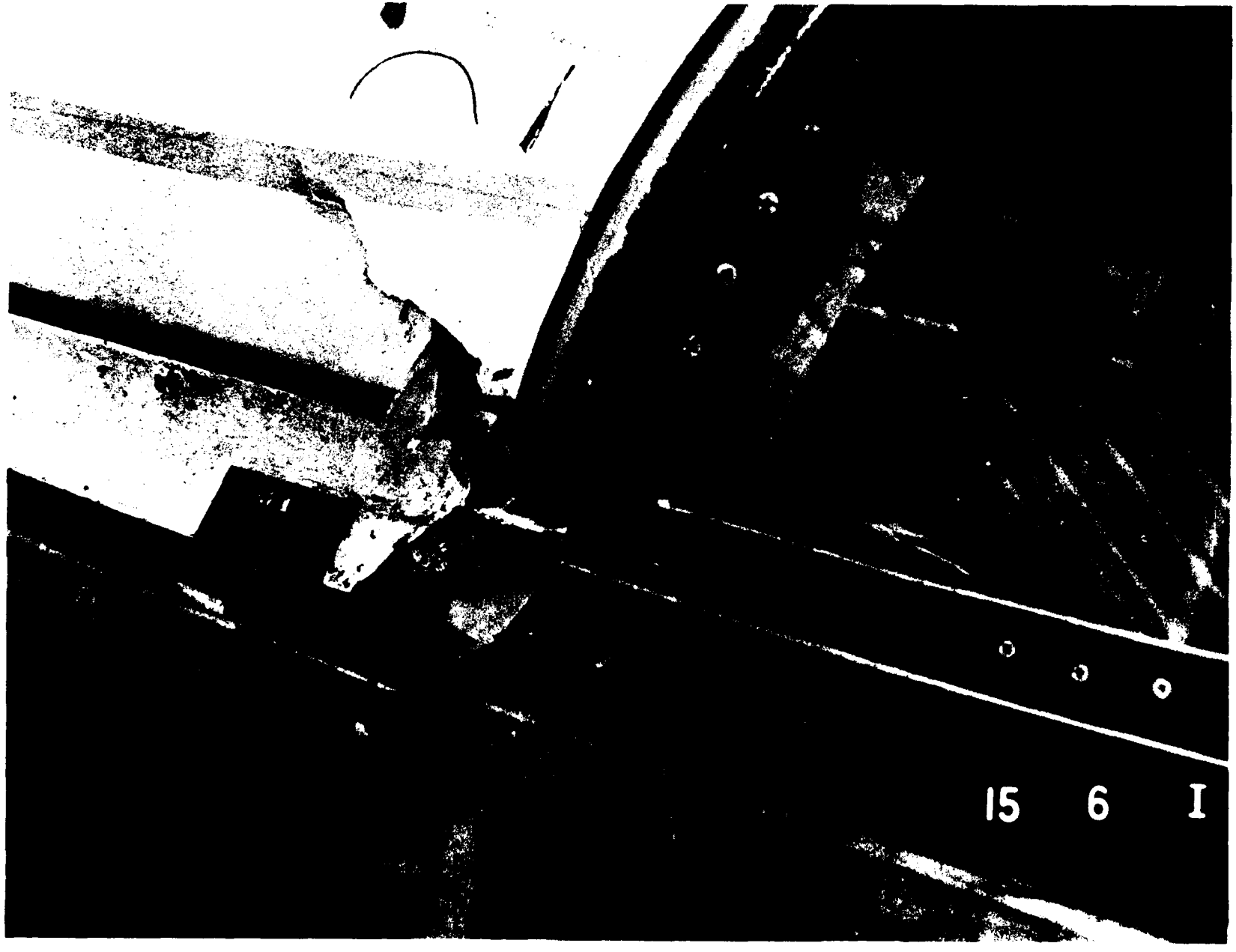


Photograph #6. Post-Test Center View
Shot #156



Photograph #7. Center Of Aft Arch Support Shot #156

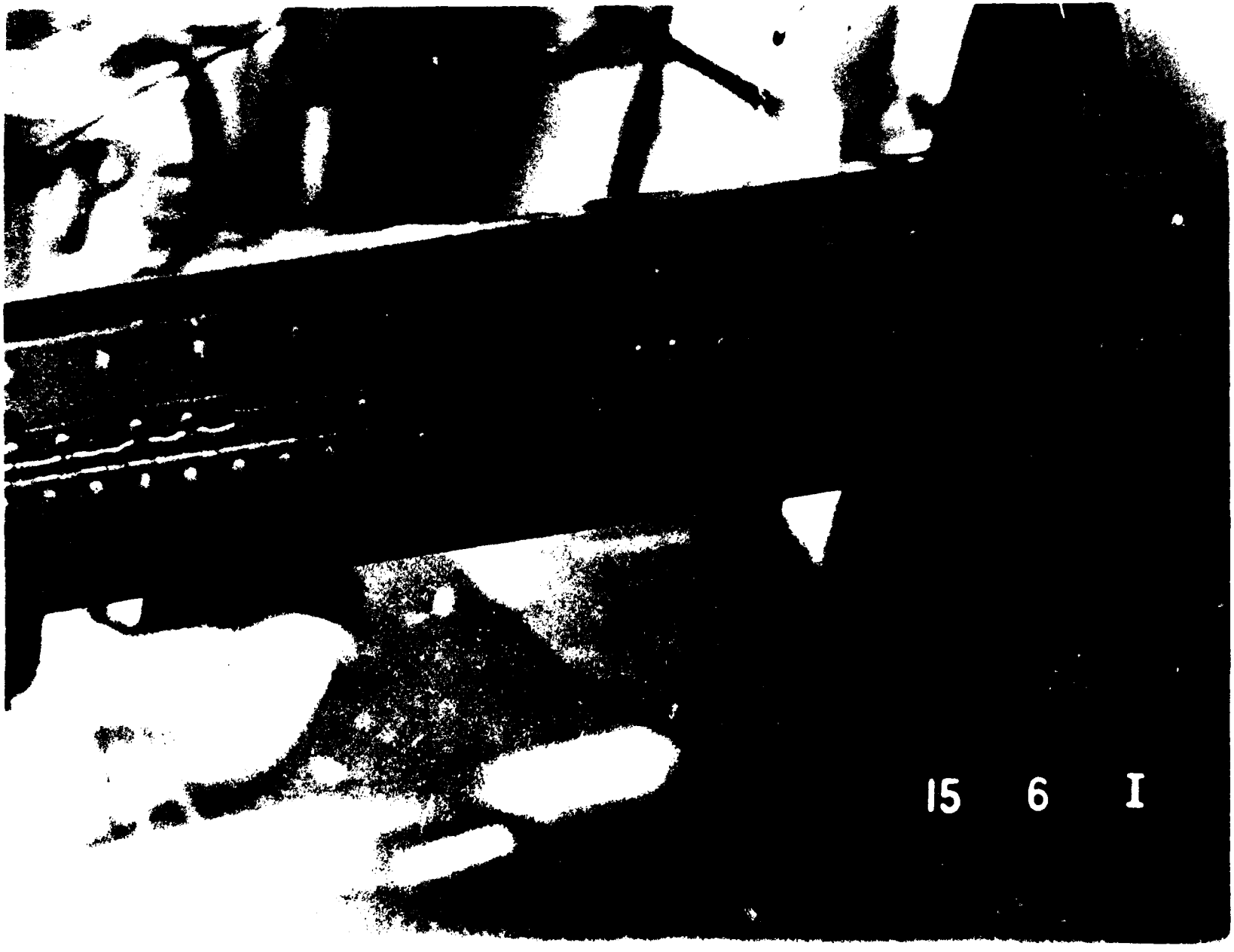
Photograph #8. Post-Test Side View
Shot #156



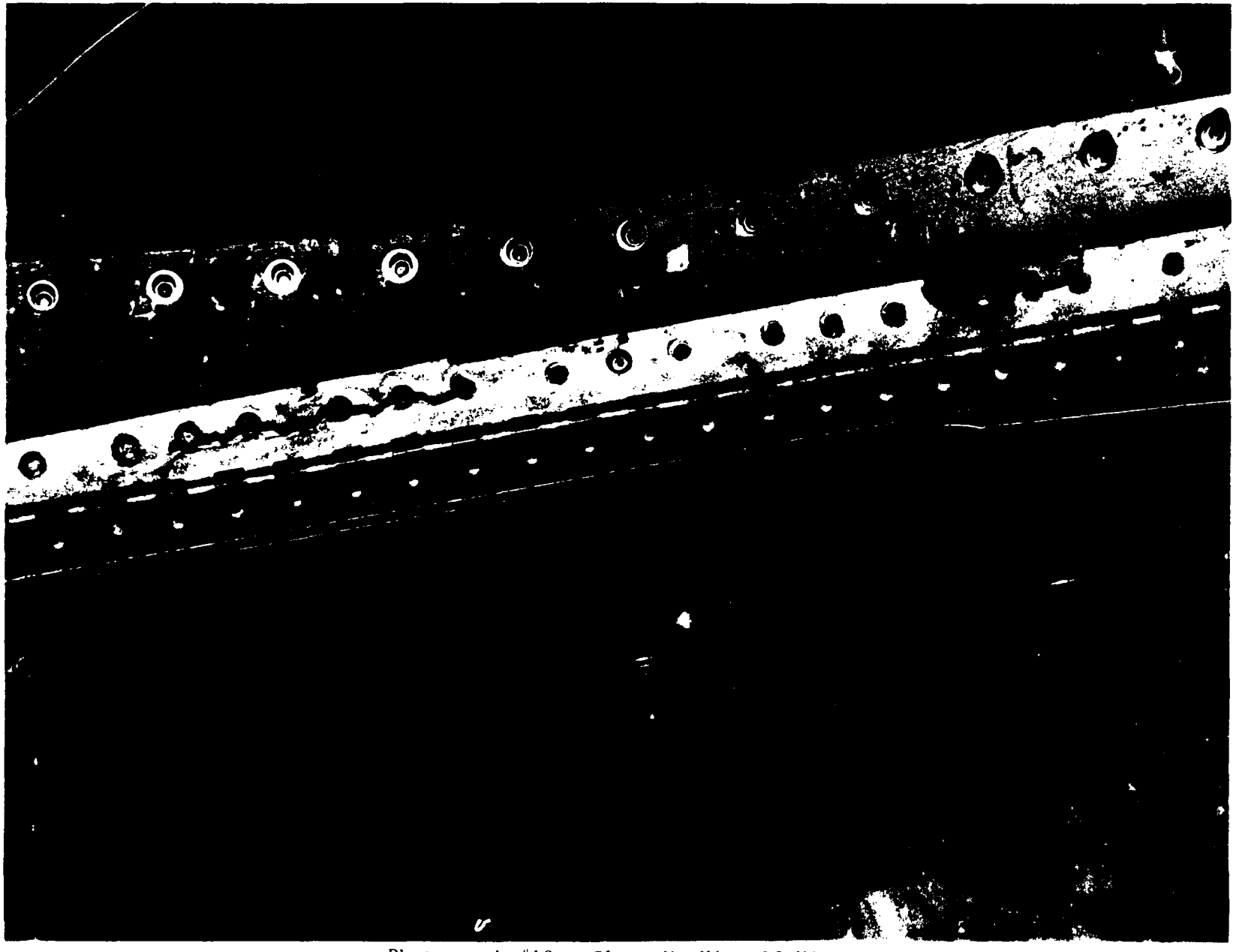
Photograph #9. Post-Test Lower W/S &
Canopy Frame Shot #156

Photograph #10. Post-Test 1/4 Point Of Arch Shot #156

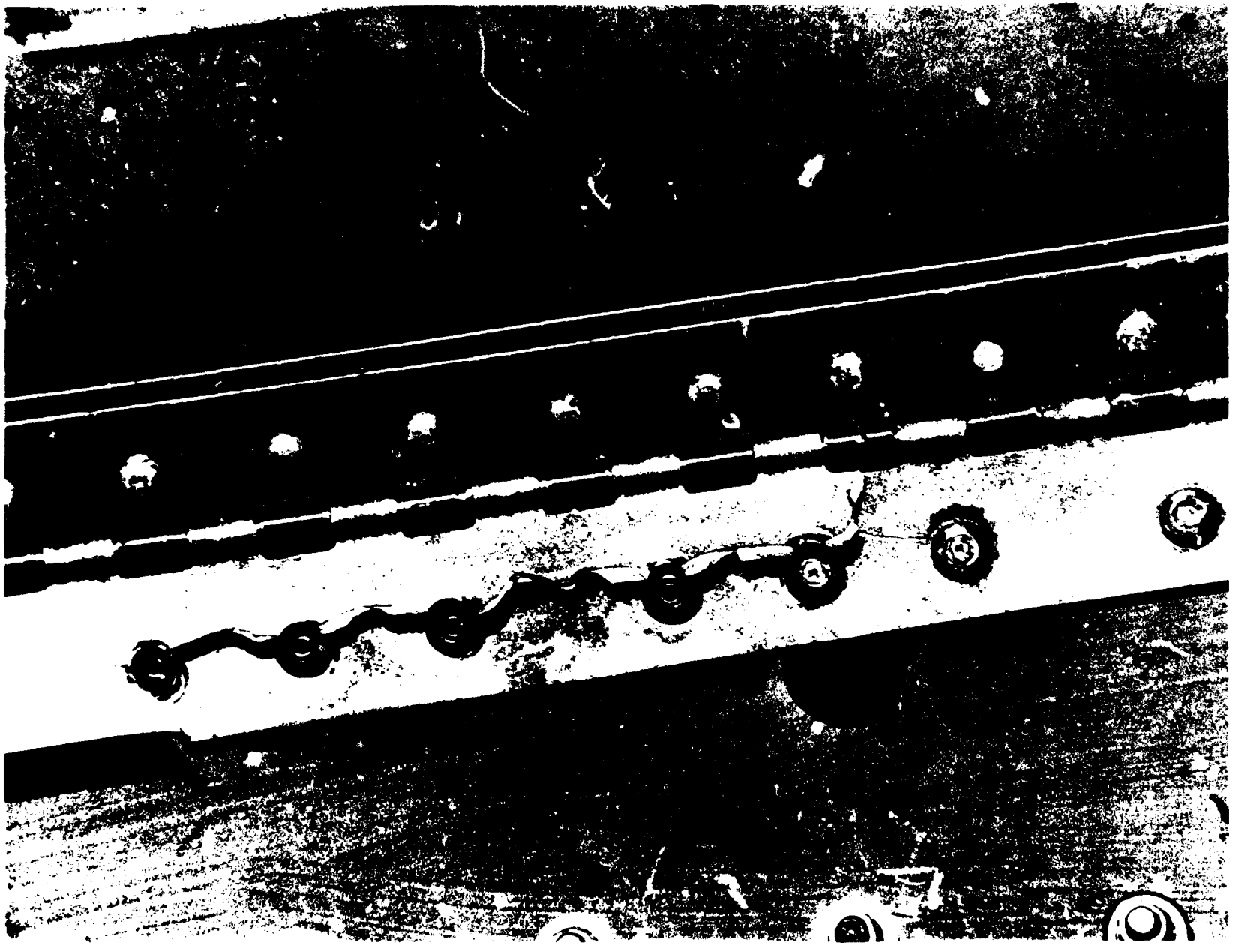
Photograph #11. 1/4 Point Close Up View
Shot #156



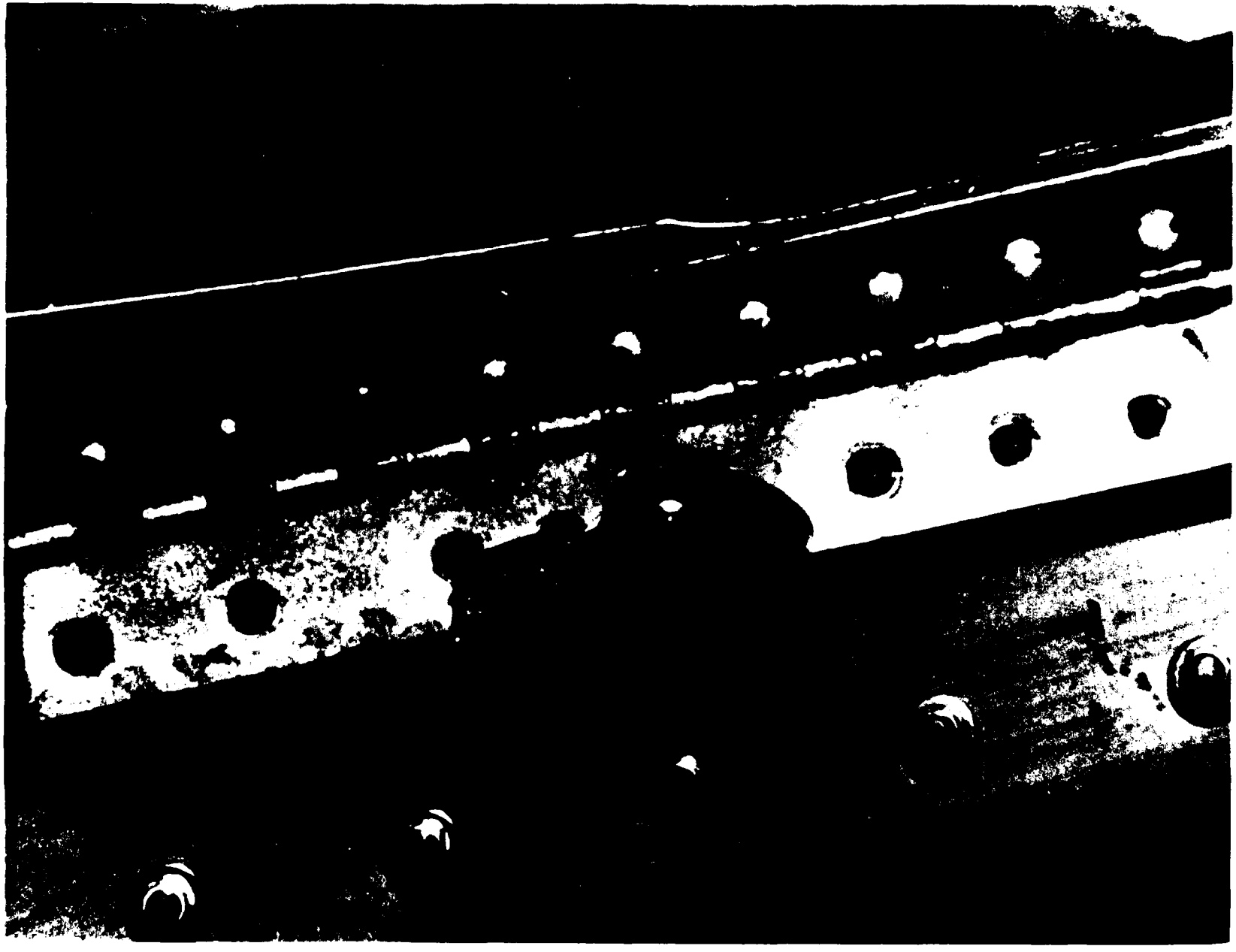
Photograph #12. Attachment Hinge
Post-Test Shot #156



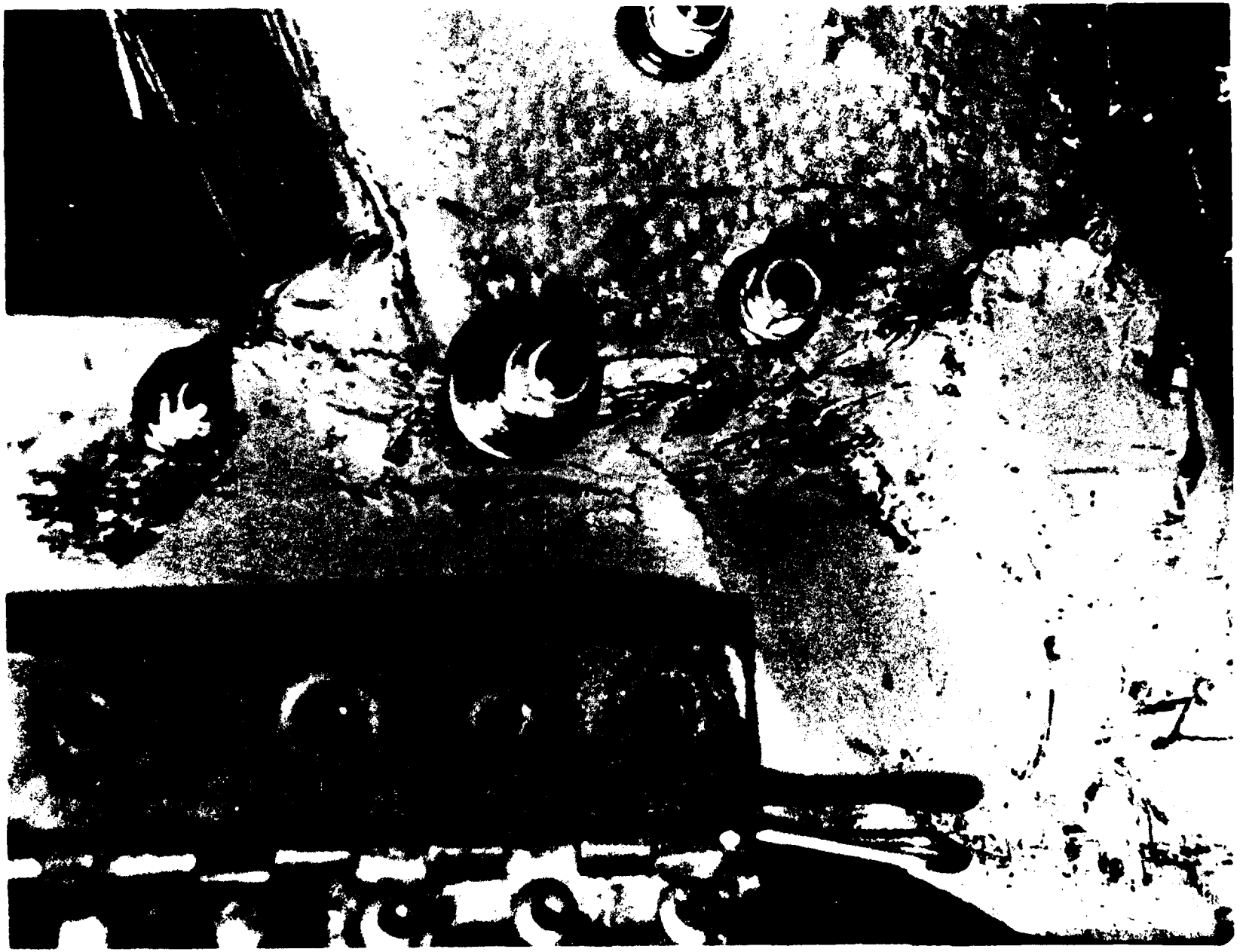
Photograph #13. Close Up View Of Hinge
Shot #156



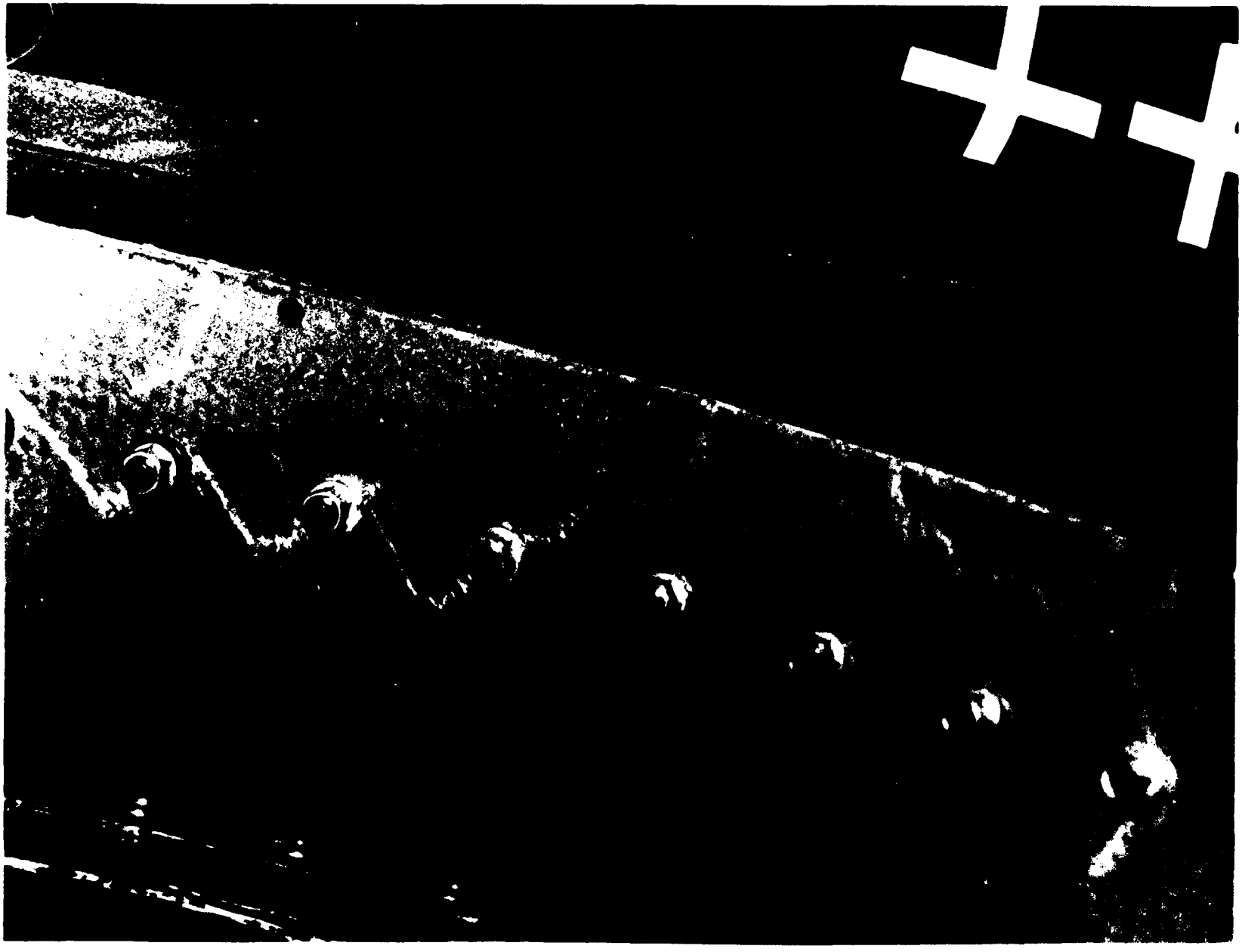
Photograph #14. Zoom View Of Hinge
Right Side Shot #156



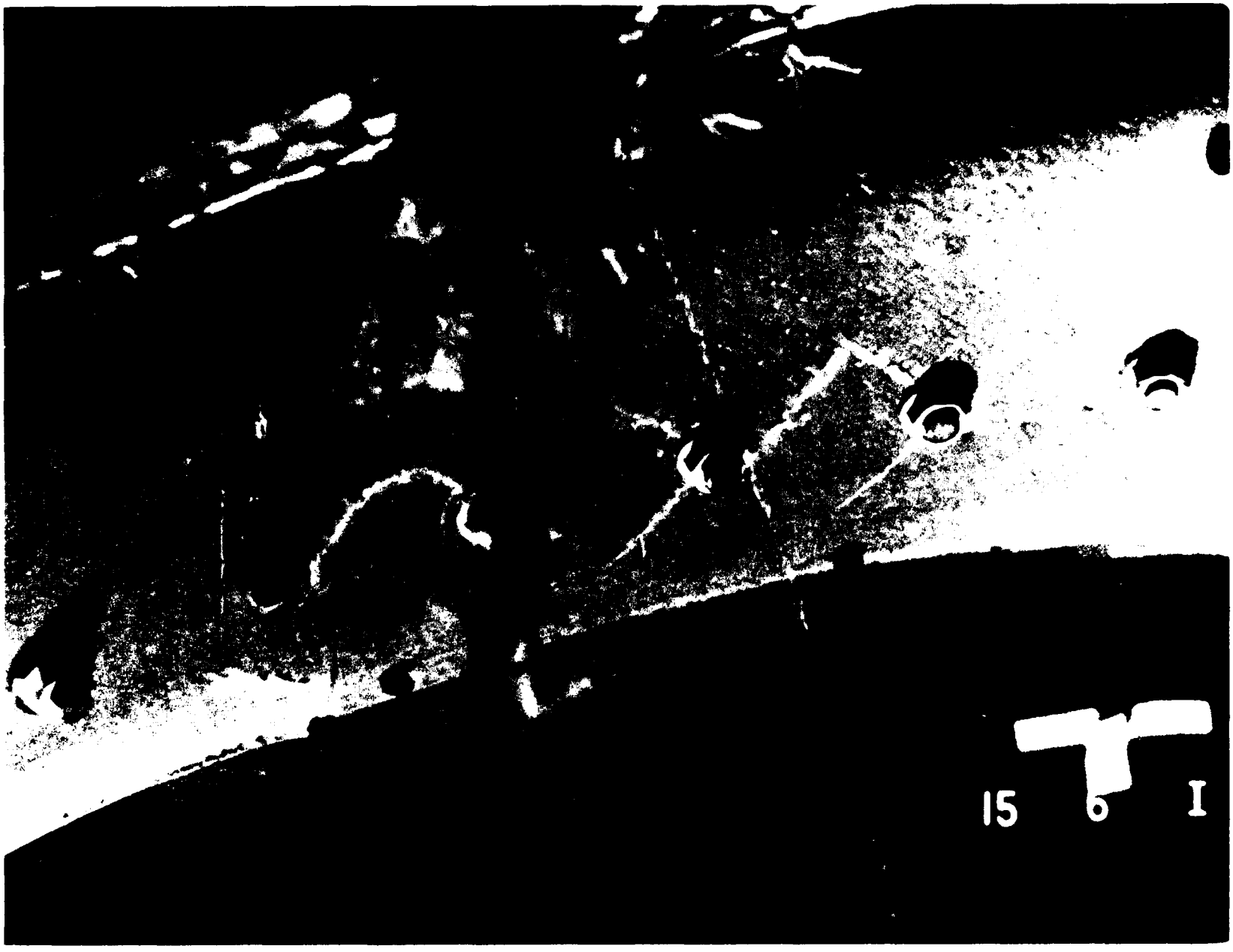
Photograph #15. Zoom View Of Hinge
Left Side Shot #156



Photograph #16. Bottom Corner Aft
Frame Shot #156



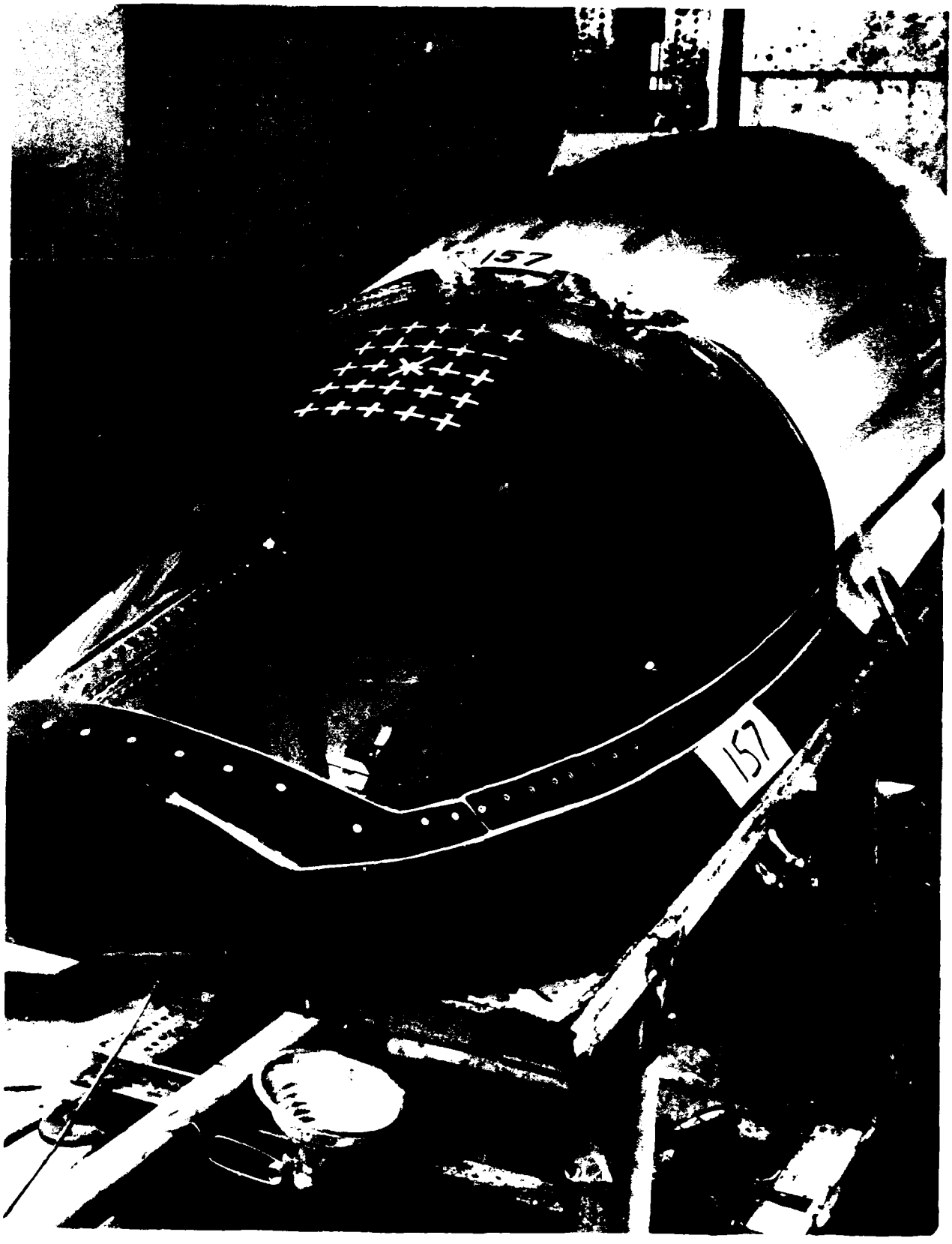
Photograph #17. Composite Arch
Reinforcement Shot #156



Photogrpah #18. Composite Arch
Reinforcement Shot #156

Photograph #19. Close Up Of Hinge &
Hinge Pin Shot #156

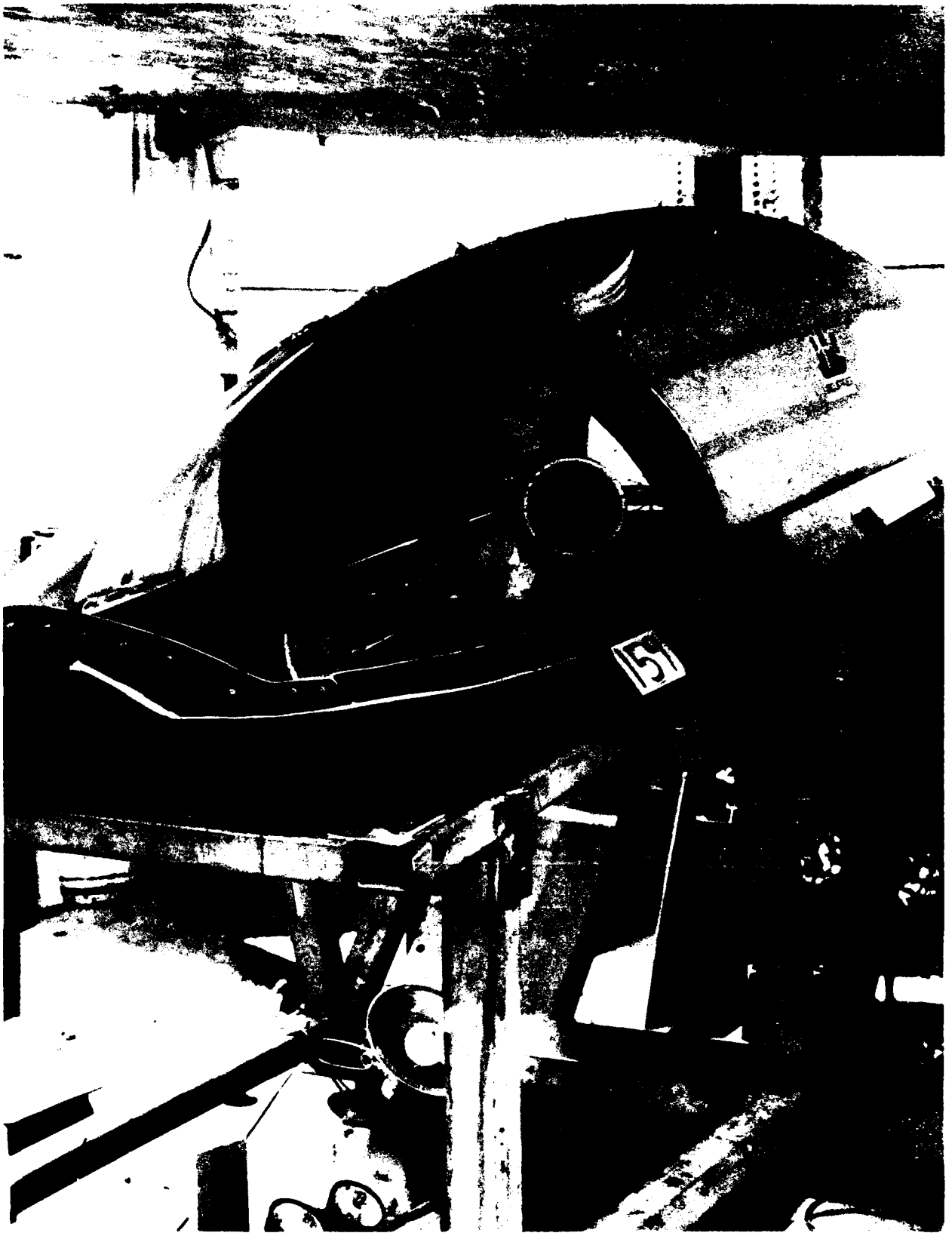
Photograph #20. Canopy & Frame Post-Test Shot #156



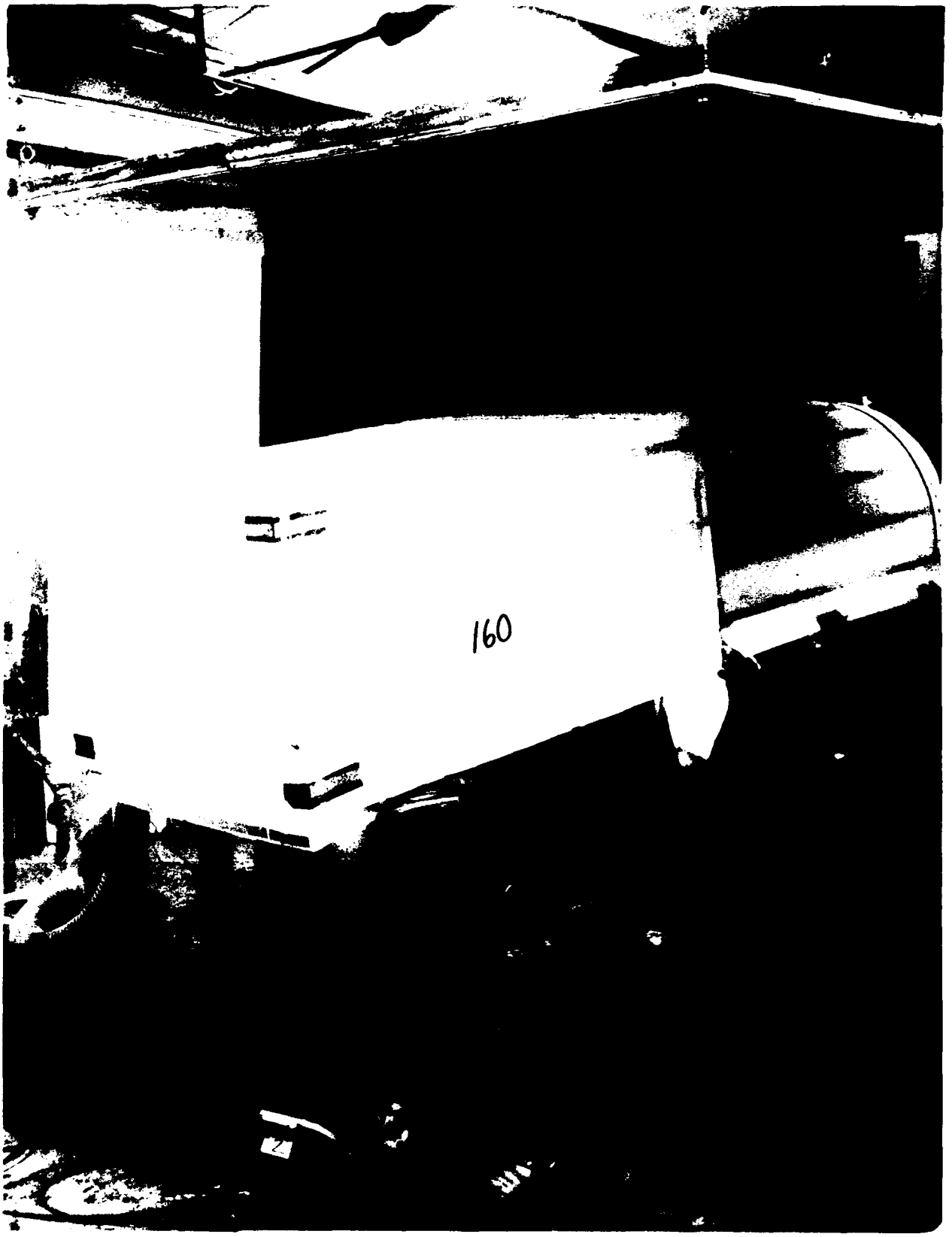
Photograph #21. Overall Post-Test
Shot #157

Photograph #22. Witness Plate Head
Post-Test Shot #157

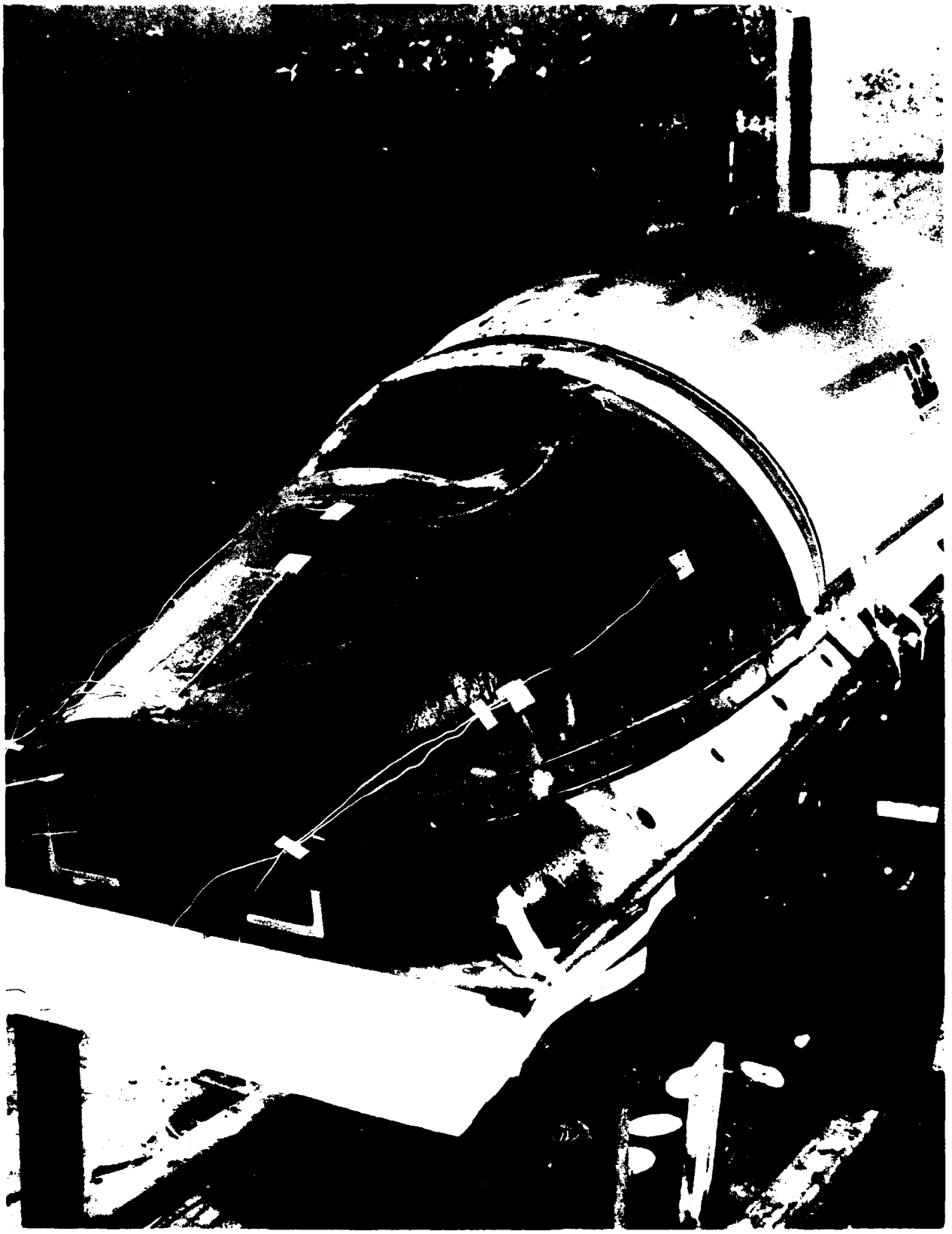
Photograph #23. Overall Post-Test
Shot #158



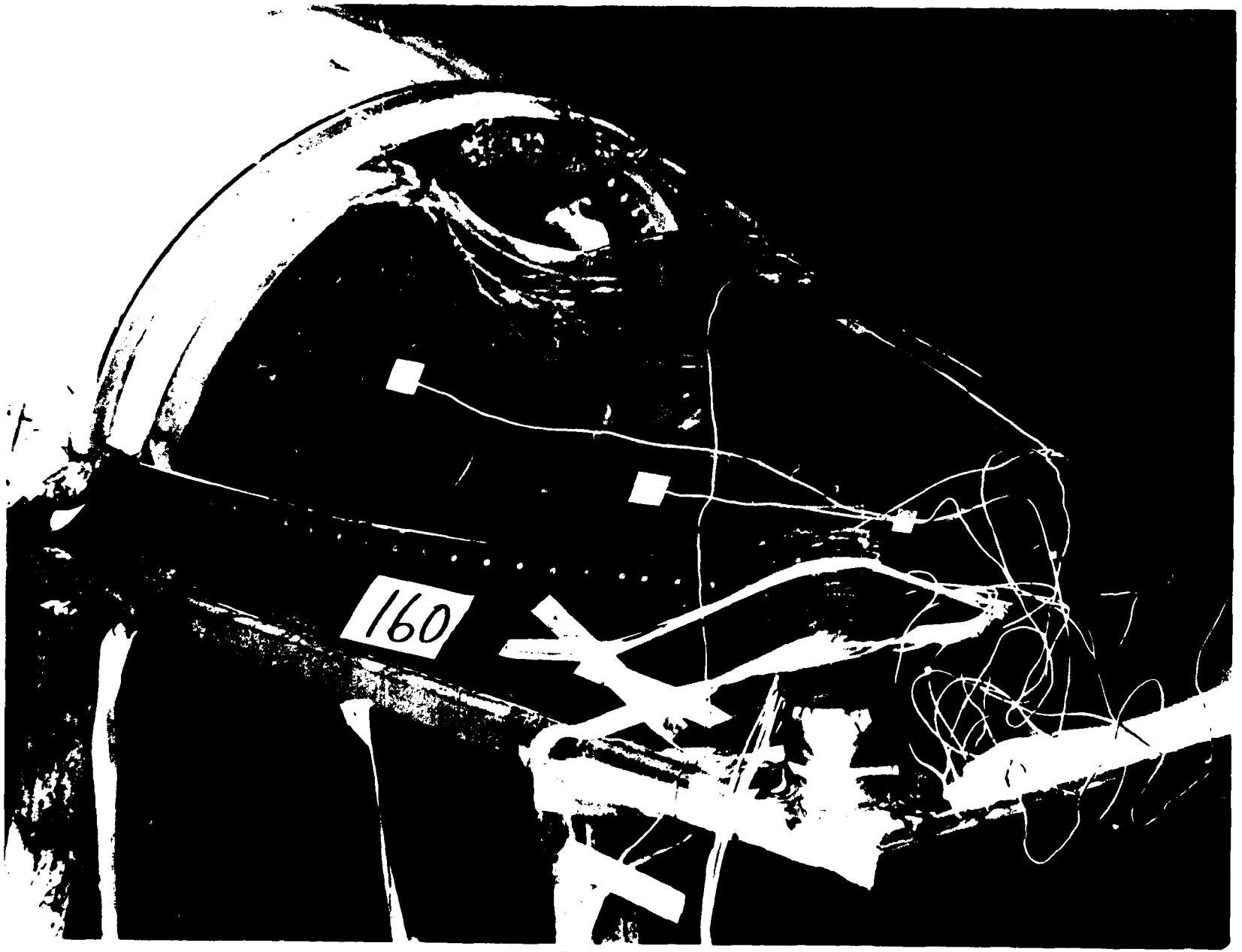
Photograph #24. Overall Post-Test
Shot #159



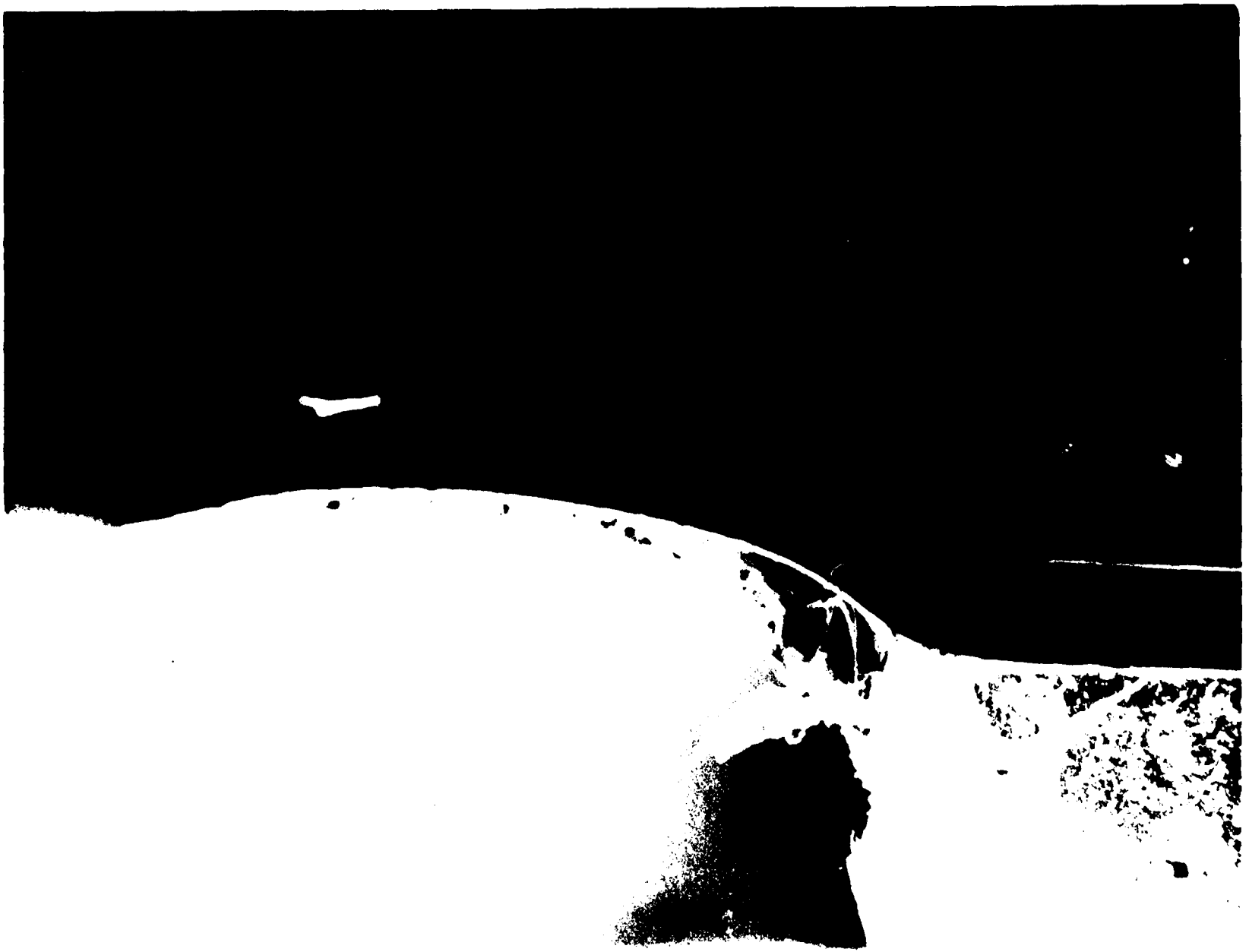
Photograph #25. Pre-Test Setup Cold Shot Shot #160



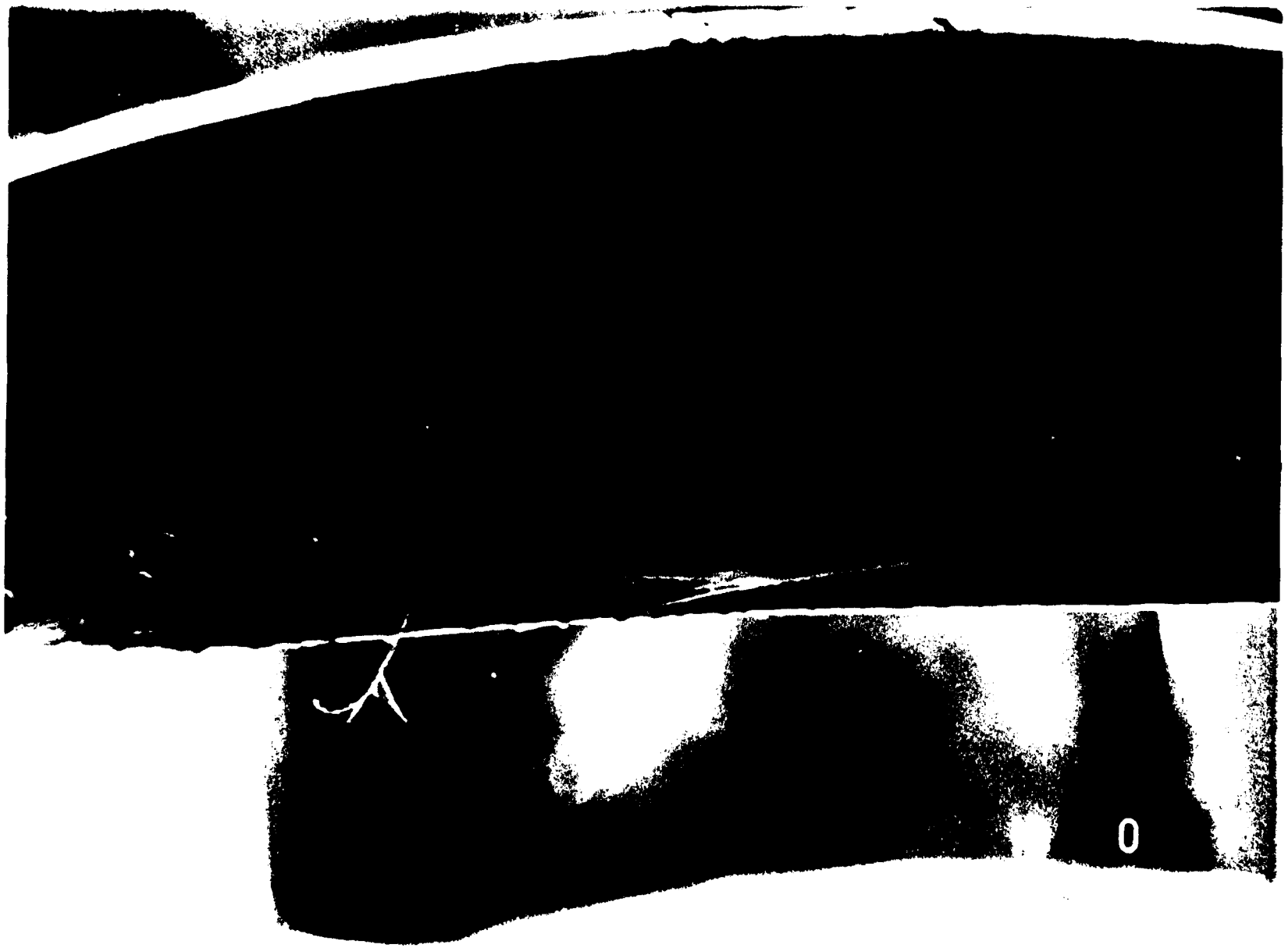
Photogrpah #26. Overall Post-Test
Shot #160



Photogrpah #27. Side View Post-Test
Shot #160



Photograph #28. View Of Aft Arch From Inside Shot #160



Photograph #29. View Of Aft Arch From
Aft Shot #160

Photograph #30. View Of Aft Arch From Forward Shot #160

APPENDIX B

BIRD IMPACT TEST REPORTS
T-38 ALTERNATIVE TRANSPARENCIES
AUGUST 9, THROUGH AUGUST 15, 1985

BIRD IMPACT TEST REPORT
T-38 ALTERNATIVE TRANSPARENCIES
8/9/85 THROUGH 8/15/85

PPG INDUSTRIES, INC.
AIRCRAFT PRODUCTS DIVISION
TECHNOLOGY DEVELOPMENT GROUP
HUNTSVILLE, ALABAMA

PREPARED BY: H. E. Goodrich

H. E. Goodrich
Senior Development Engineer

9-4-85
Date

APPROVALS

APPROVED BY: W. E. Heidish by PBW — 9-6-85
W. E. Heidish
Technical Director
Date

APPROVED BY: P. B. Walters — 9-6-85
P. B. Walters, Manager
Testing and Product Reliability
Date

APPROVED BY: W. F. Rothe — 9/5/85
W. F. Rothe, Manager
New Products Design and Development
Date

APPROVED BY: J. W. Myers — 9/4/85
J. W. Myers
Project Engineer
Date

TABLE Of CONTENTS

1.0 OBJECTIVE

The objective of this test program was to evaluate the T-38 windshield and edge attachment design as a unit under bird impact and environmental conditions combined. Four windshields were to be impacted with the number of impacts per windshield and frame numbers used as defined by the test results of earlier shots and also by the preceding shot evaluations.

2.0 TEST PROCEDURE

The test program was to be managed using the test evaluations of previously conducted shots as well as the data generated by the immediately preceding test shot results. All impacts would be done with four pound birds at velocities determined by the program director. This approach was chosen to allow a definition of the penetration velocity of the transparency at specific test temperatures. The test temperatures were to be either ambient room temperature or cold (25°F).

3.0 TEST RESULTS

Six bird impacts were made on four test windshields during the completion of this portion of the test program. Two of the windows were impacted twice with the remaining two tested only once.

The first shot (#184) was made at 393.1-knots on windshield number 322-54 with a 4.002-pound bird at a room temperature of 70°F. The window passed with no major damage other than an approximate permanent deflection of 1/4-inch in the aft arch. Several pieces of the arch material were removed by the impact. The test also permitted a few pieces of bird residue to hit the witness plate.

Shot #185 was conducted on windshield number 322-72 with a 4.012-pound bird at 400.9-knots and proved to be a failure. The impact was made after cold soaking the panel at 25°F for a period of 15-minutes. A flap of some 12-inches by 8-inches opened up in the impact area and allowed bird to enter cockpit.

Shot #186 was conducted on windshield number 322-57 after a cold soak as described for the previous shot. The speed was 393.2-knots with a 4.014-pound bird and also proved to be a failure. Again an approximate 12-inch by 8-inch flap was opened allowing some bird to enter the cockpit area. Several cracks were generated from the flap area toward the forward arch. These first three shots were made at a location 9-inches forward of the aft arch on the center line of the windshield.

Shot #187 was made on panel number 322-54 which had previously been impacted on shot #184. The impact point on this test was located 6-inches aft of the forward sill on the center line of the panel. The shot was made at room

temperature with a 4.016-pound bird and a velocity of 396.2-knots and the window passed. Cracks from the previous shot damage propagated across the windshield center.

Shot #188 was conducted at room temperature at the center of the window on the center line. Windshield number 322-52, which had been tested on shot numbers 156, 157, 158, and 159 was again used for this test. A 4.002-pound bird impacted the windshield at 392.5-knots without damaging the panel. There was no penetration nor visible damage from the test.

Once more, windshield number 322-52 was used on shot #189. The impact location was changed back to the same position as used in the first three shots namely 9-inches forward of the aft arch on the center line of the window. This time the test was conducted after a 15-minute cold soak at 25°F. The impact was made at 302.1-knots with a 3.998-pound bird and produced no damage to the window.

Copies of all of the test data sheets appear in Appendix I. Photographs of a typical test set up and post test results of each test appear in Appendix II.

APPENDIX I
DATA RECORDINGS

(1)

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO 322-81
SAMPLE IDENTIFICATION CODE: 322-54 CLASSIFICATION:
TEST DATE REQUESTED: 8-9-85 REQUESTED BY: J.W. Myers
PANEL TYPE: FULL SIZE X 26"x26" ____ BOLTED X CLAMPED ____ OTHER ____
MOUNTING FRAME: RIGID ____ FLEXIBLE ____ OTHER X FRAME # 1368
PANEL CROSS SECTION:

5300 Liner
3/8 Poly
.060 PPG 112
8/16 Poly
8500 Coating

Ref. Figure 1 T-38 Test Plan - Bird Impac
Hexcel Aft Arch outboard Retainer

HIGH SPEED FILM: YES (X) 3 NO ( ) THERMOCOUPLES YES ( ) NO (X)
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	AMBIENT	70°F
TEMPERATURE OUTBOARD	AMBIENT	70°F
BIRD WEIGHT	4 lb	4.002
BIRD SPEED	400 Knots	393.1

AMBIENT TEMP: ____
IMPACT LOCATION: 9" Fwd of Aft Arch CL
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: —

Ref Fig 4 T-38 Bird Impact Test Plan

TEST RESULTS: SHOT NO: 184 TEST DATE: 8/9/85 TESTED BY: H.E.G.

OBSERVATION: No penetration. Aft arch shows approx. 1/4" permanent deflection. Few pieces of bird residue on witness plate. Aft arch strap peeled in impact area.

PPG WITNESS Thomas D. Stewart CUSTOMER WITNESS ____

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

(2)

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO-322-81
SAMPLE IDENTIFICATION CODE: 322-72 CLASSIFICATION:
TEST DATE REQUESTED: 8-12-85 REQUESTED BY: J. W. Myers
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X FRAME #1598
PANEL CROSS SECTION:
5300 LINER
3/8 Poly
.060 PPG 112
3/16 Poly
8500 COATING

REF FIGURE 1 T-38 TEST PLAN - BIRD IMPACT
HEXCEL AFT ARCH OUTBOARD RETAINER

HIGH SPEED FILM: YES (X) 3 NO ( ) THERMOCOUPLES YES (X) NO ( )
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD		50°F
TEMPERATURE OUTBOARD	+25° F	22°F *
BIRD WEIGHT	4 lb	4.012
BIRD SPEED	400 KNOTS	400.9

AMBIENT TEMP: ___
IMPACT LOCATION: 9" FWD AFT ARCH CL
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: ___
REF. FIG. 4 T-38 BIRD IMPACT TEST PLAN

Hold AT +25°F FOR 15 MIN THEN SHOOT

TEST RESULTS: SHOT NO: 185 TEST DATE: 8/12/85 TESTED BY: H.E.G.

OBSERVATION: WS FAILED. FLAP (APPROX. 12" x 8") OPENING IN IMPACT AREA. SEVERAL CRACKS IN LINER SURFACE.

PPG WITNESS Herman D. Stewart CUSTOMER WITNESS ___

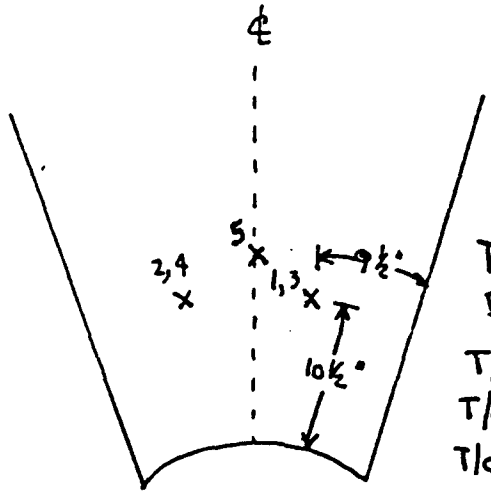
DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

* TEMP. AFTER 15 MINUTE SOAK AT 25°F.

T-38 Bird Impact

Shot #185 Thermal Data 8-12-85

Time	T/C# 1	2	3	4	5
1:15	80	80	83	78	77
1:20	57	61	77	77	66
1:25	32	37	70	73	65
1:28	23	32	66	68	60
1:33	23	26	59	60	63
1:38	23	26	53	55	63
1:42	22	25	50	51	63
1:44	IMPACT				



TYPICAL DIMENSIONS
BOTH SIDES.
T/C # 1 & 2 OUTBOARD
T/C # 3 & 4 INBOARD
T/C # 5 10" OFF INBOARD SURFACE

③

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: T-38 R&D Contract F-33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO-322-81
SAMPLE IDENTIFICATION CODE: 322-57 CLASSIFICATION:
TEST DATE REQUESTED: 8-13-85 REQUESTED BY: J.W. Myers
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X FRAME 1570
PANEL CROSS SECTION: old Composite Material

5300 Layer
3/8 Poly
.060 PPG 112
3/16 Poly
8500 Coating

REF. FIGURE 1 T-38 TEST PLAN
BIRD IMPACT

INBOARD Stainless Steel
RETAINER REMOVED BEFORE Impact

HIGH SPEED FILM: YES (X) 3 NO ( ) THERMOCOUPLES YES (X) NO ( )
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD		51°F
TEMPERATURE OUTBOARD	+25° F	24°F*
BIRD WEIGHT	4 lb	4.014
BIRD SPEED	400 Knots	393.2

AMBIENT TEMP: ___
IMPACT LOCATION: 9" FWD AFT ARCH ℄
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: ___
REF. FIG. 4 T-38 TEST PLAN BIRD Impact

Hold AT +25°F FOR 15 min THEN SHOOT

TEST RESULTS: SHOT NO: 186 TEST DATE: 8/13/85 TESTED BY: H.E.G.

OBSERVATION: PANEL FAILED. FLAP (12"x8") OPENED IN IMPACT AREA. SEVERAL CRACKS RADIATING TOWARD FORWARD ARCH FROM FLAP EDGE.

PPG WITNESS Sherman D. Stewart CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

* TEMP. AFTER 15 MINUTE SOAK AT 25°F.

T-38 Bird Impact

Shot #186 — Thermal Data — 8-13-85

Time	T/C# 1	2	3	4	5	
1:17	51	55	84	83	70	
1:26	26	31	62	74	71	* Cooling off for 8 min. for camera film loading
1:29	24	28	70	70	65	
1:31	27	34	65	66	65	
1:34	23	28	60	60	65	
1:38	24	28	55	56	65	
1:43	24	26	51	52	72	
1:45	IMPACT					

(4)

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO-322-81
SAMPLE IDENTIFICATION CODE: 322-54 CLASSIFICATION:
TEST DATE REQUESTED: 8-14-85 REQUESTED BY: J.W. Myers
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X FRAME #1368
PANEL CROSS SECTION:

5300 LINER
3/8 Poly
.060 PPG 112
3/16 Poly
8500 COATING

REF FIGURE 1 T-38 TEST PLAN BIRD IMPACT

THIS PANEL PREVIOUSLY IMPACTED SHOT # 184

HIGH SPEED FILM: YES (X) 3 NO ( ) THERMOCOUPLES YES ( ) NO (X)
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	AMBIENT	76°F
TEMPERATURE OUTBOARD	AMBIENT	76°F
BIRD WEIGHT	4 lb	4.016
BIRD SPEED	400 KNOTS	396.2

AMBIENT TEMP: ___
IMPACT LOCATION: 6" AFT OF FWD ARCH
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: ___

REF. FIG. 4 T-38 TEST PLAN BIRD IMPACT

TEST RESULTS: SHOT NO: 187 TEST DATE: 8/14/85 TESTED BY: H.E.G.

OBSERVATION: W/S PASSED. CRACKS FROM PREVIOUSLY SHOT AREA AT AFT ARCH PROPAGATED ACROSS W/S CENTER.

PPG WITNESS Thomas D. Stewart CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

(5)

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO-322-81
SAMPLE IDENTIFICATION CODE: 322-52 CLASSIFICATION:
TEST DATE REQUESTED: 8-15-85 REQUESTED BY: G.W. Myers
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X FRAME # 1570
PREVIOUSLY IMPACTED #186
PANEL CROSS SECTION:
5300 LINER
3/8 Poly
.060 PPG 112
3/16 Poly
8500 COATING

REF. FIGURE 1 T-38 TEST PLAN
BIRD IMPACT

INBOARD S.S. RETAINER REMOVED BEFORE IMPACT.
THIS PANEL PREVIOUSLY IMPACTED # 156, 157, 158, 159

HIGH SPEED FILM: YES (X) 3 NO ( ) THERMOCOUPLES YES ( ) NO (X)
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	AMBIENT	72°F
TEMPERATURE OUTBOARD	AMBIENT	72°F
BIRD WEIGHT	4 lb	4.002
BIRD SPEED	400 KNOTS	392.5

AMBIENT TEMP: ___
IMPACT LOCATION: CENTER OF ℄
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: ___
REF FIG. 4 T-38 TEST PLAN
BIRD IMPACT

TEST RESULTS: SHOT NO: 188 TEST DATE: 8/15/85 TESTED BY: H.E.G.

OBSERVATION: W/S PASSED. NO PENETRATION.

PPG WITNESS Norman D. Stewart CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE. H. GOODRICH

(6)

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO-322-81
SAMPLE IDENTIFICATION CODE: 322-52 CLASSIFICATION:
TEST DATE REQUESTED: 8-15-85 REQUESTED BY: L W Myers
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X FRAME # 1570
PANEL CROSS SECTION: Previously Impact #186, 188
5300 Liner
3/8 Poly
.060 PPG 112
3/16 Poly
8500 Coating

Ref Fig. 1 T-38 Test Plan Bird Impact
Inboard S.S. Retainer Removed Before Impact.
This Panel Previously impacted #156, 157, 158, 159, 188

HIGH SPEED FILM: YES (X)[3] NO ( ) THERMOCOUPLES YES (X) NO ( )
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD		56°F
TEMPERATURE OUTBOARD	+25° F	25°F *
BIRD WEIGHT	4 lbs	3.998
BIRD SPEED	300 Knots	302.1

AMBIENT TEMP: ___
IMPACT LOCATION: 9" Fwd of Aft Arch &
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: ___
Ref Fig. 4 T-38 Test Plan Bird Impact

Hold at +25°F for 15 min. then Shoot.

TEST RESULTS: SHOT NO: 189 TEST DATE: 8/15/85 TESTED BY: H.E.G.

OBSERVATION: W/S Passed. No Penetration.

PPG WITNESS Thomas D. Stewart CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

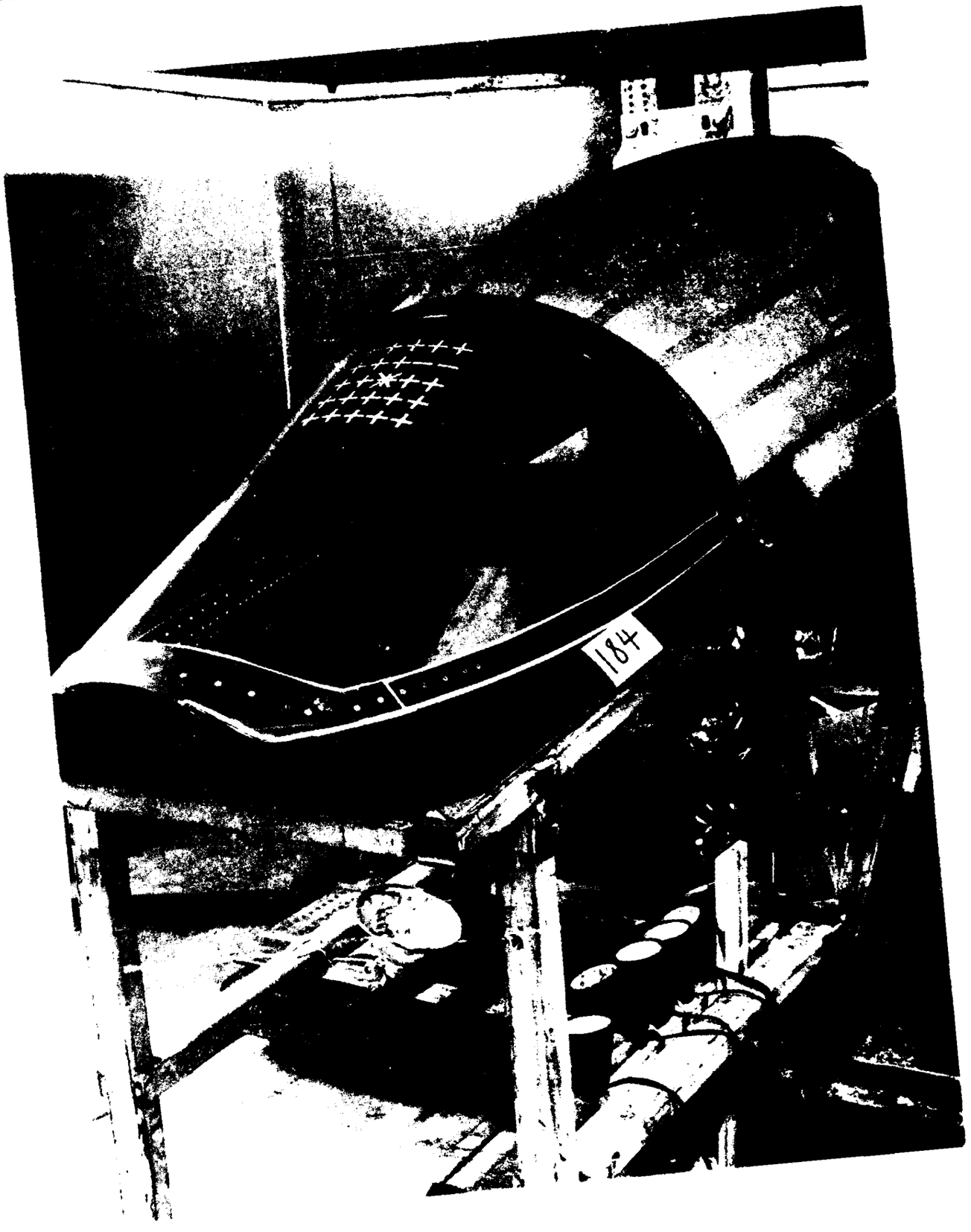
* Temp. after is minute soak at 25°F.

T-38 Bird Impact

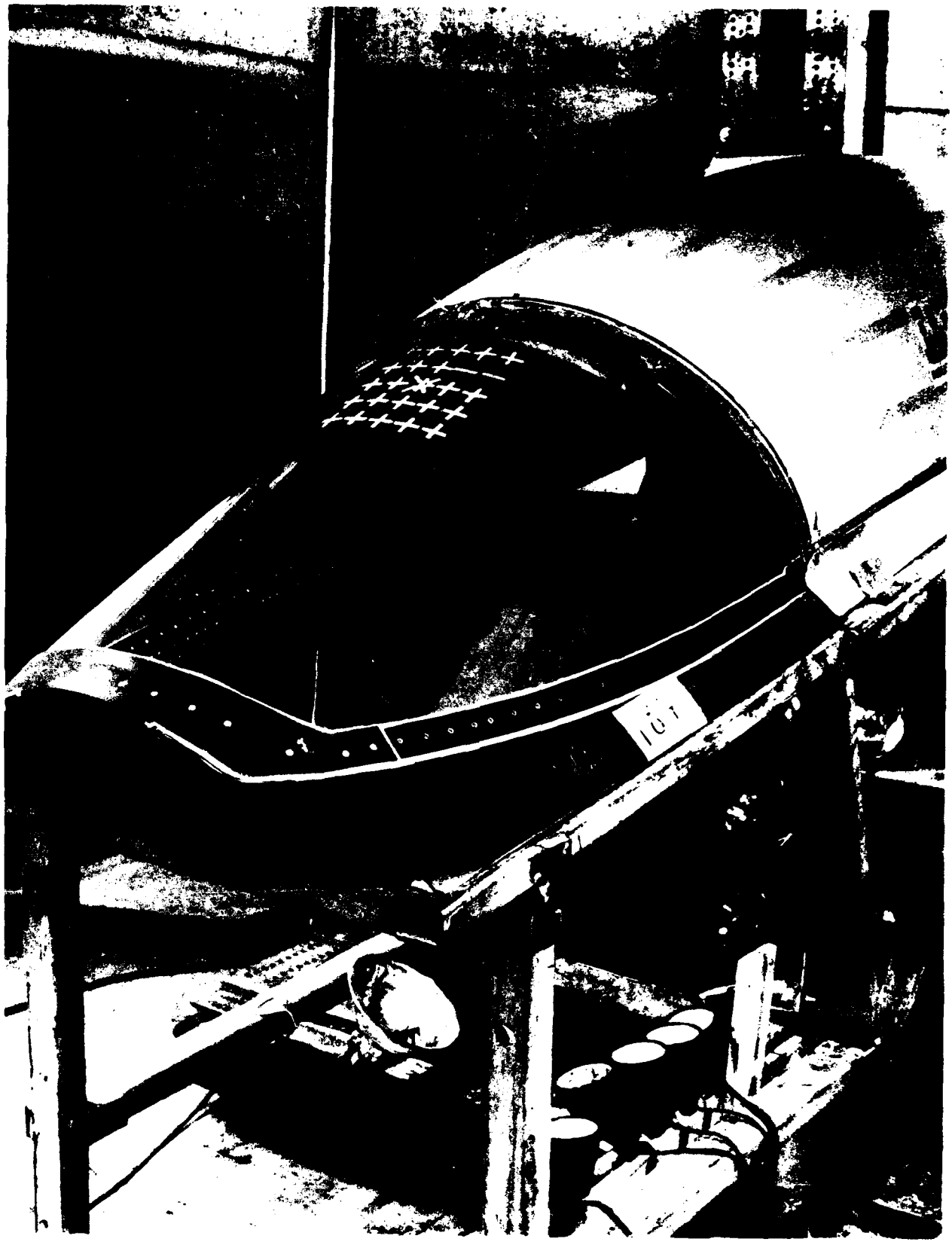
Shot #189 — Thermal Data — 8-15-85

Time	T/C# 1	2	3	4	5
12:25	24	34	75	75	70
12:29	22	30	71	72	69
12:32	26	33	67	68	68
12:34	22	29	61	62	68
12:36	22	29	58	59	67
12:38	23	29	56	57	69
12:40	IMPACT				

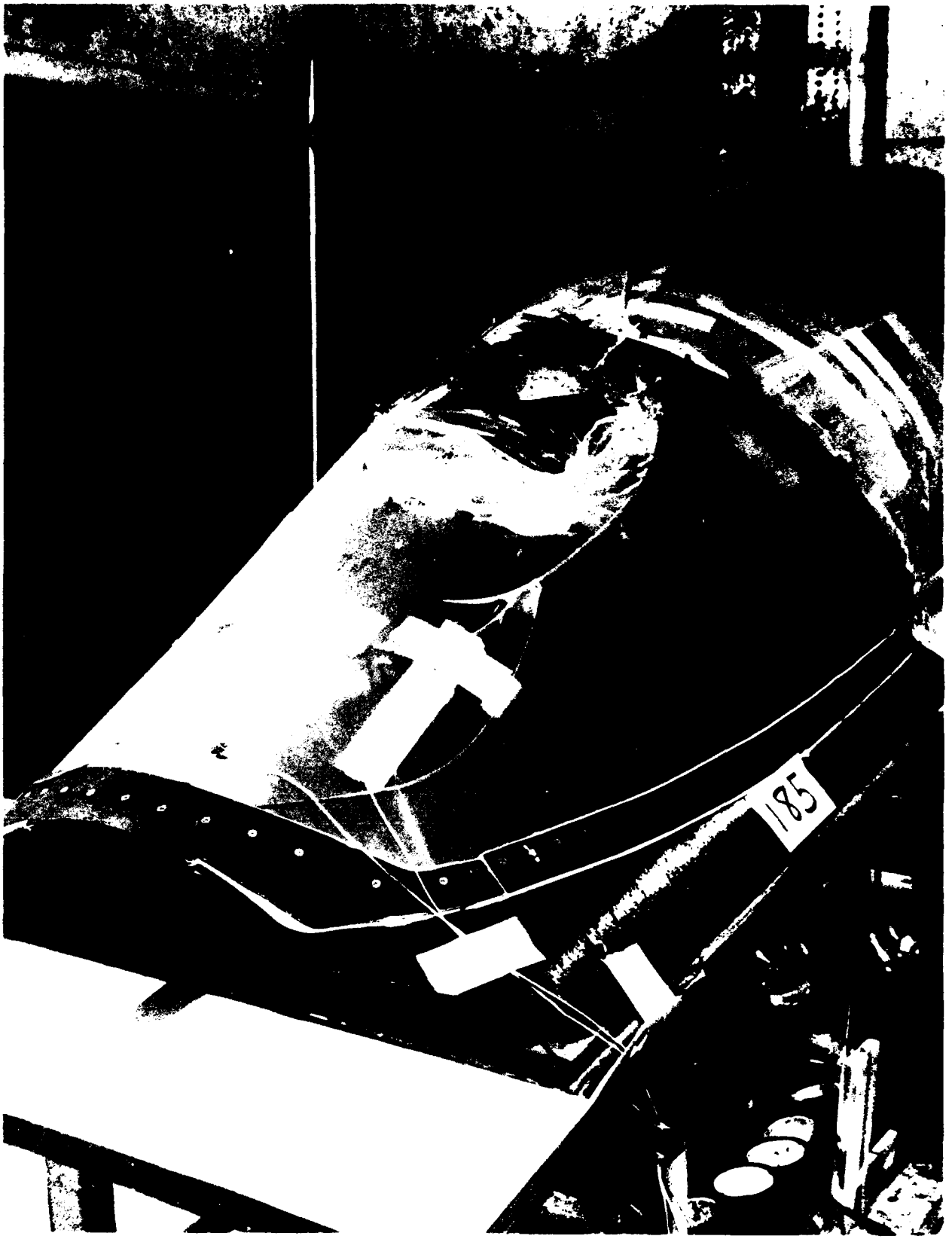
APPENDIX II
PHOTOGRAPHS



PHOTOGRAPH #1
PRE-TEST SET UP
SHOT #184

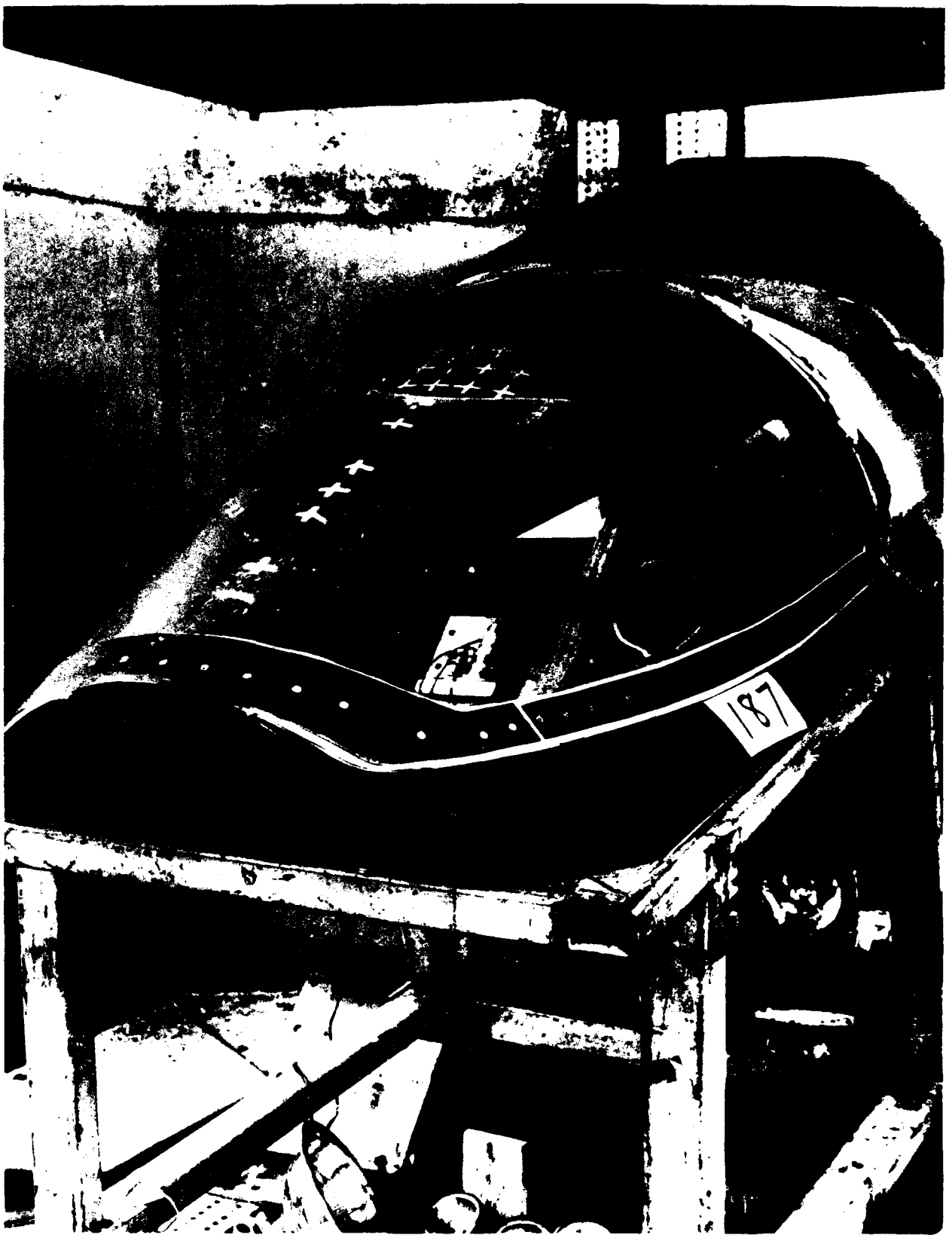


PHOTOGRAPH #2
POST TEST RESULTS
SHOT #184



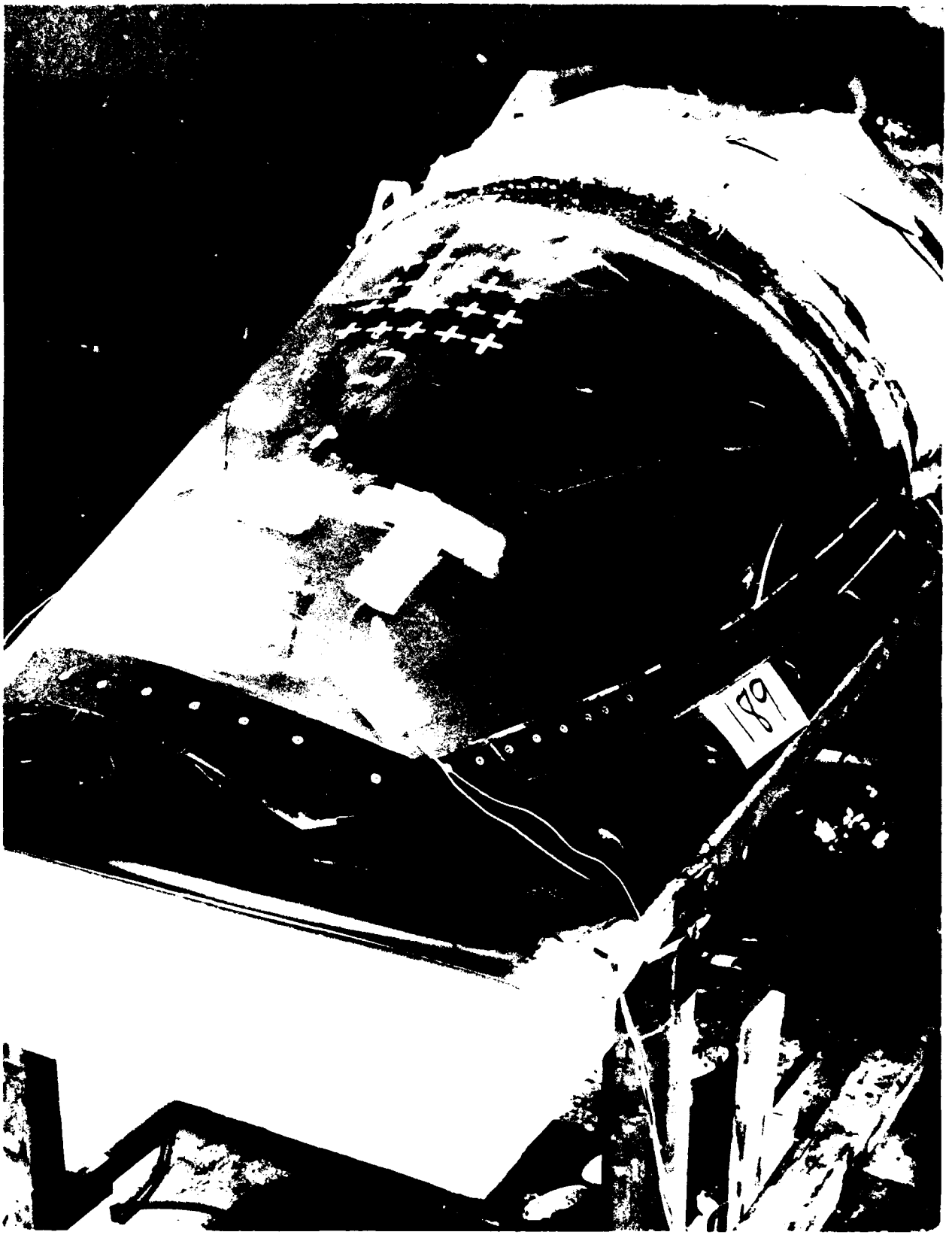
PHOTOGRAPH #3
POST TEST RESULTS
SHOT #185

PHOTOGRAPH #4
POST TEST RESULTS
COLD SHOT #186



PHOTOGRAPH #5
POST TEST RESULTS
SHOT #187

PHOTOGRAPH #6
POST TEST RESULTS
SHOT #188



PHOTOGRAPH #7
POST TEST RESULTS
COLD SHOT #189

APPENDIX C

BIRD IMPACT TEST REPORTS
T-38 ALTERNATIVE TRANSPARENCIES
OCTOBER 1, THROUGH OCTOBER 2, 1985
AND
NOVEMBER 14, THROUGH NOVEMBER 22, 1985

BIRD IMPACT TEST REPORT
T-38 ALTERNATIVE TRANSPARENCIES
10/1 THROUGH 10/2 1985
AND
11/14 THROUGH 11/22 1985

PPG INDUSTRIES, INC.
AIRCRAFT PRODUCTS DIVISION
TECHNOLOGY DEVELOPMENT GROUP
HUNTSVILLE, ALABAMA

PREPARED BY: H. E. Goodrich 1-14-86

H. E. Goodrich
Senior Development Engineer

Date

APPROVALS

APPROVED BY: W. E. Heidish — 1/21/86 Date
W. E. Heidish
Technical Director

APPROVED BY: P. B. Walters — 1-20-86 Date
P. B. Walters, Manager
Testing and Product Reliability

APPROVED BY: W. F. Rothe — 1/16/86 Date
W. F. Rothe, Manager
New Products Design and Development

APPROVED BY: James W. Myers — 1/16/86 Date
J. W. Myers
Project Engineer

TABLE OF CONTENTS

1.0 OBJECTIVE

The objective of this test program was to evaluate the T-38 main windshield design, as well as the instructor's window, and their respective edge attachments as a unit under bird impact and environmental conditions combined. The original test support frame was to be used in the first test series with the full size aircraft fuselage used in the second series.

2.0 TEST PROCEDURE

The test program was to be managed using the test evaluations of previously conducted shots as well as the data generated by the immediately preceding test shot. All impacts would be done with four pound birds at velocities determined by the program director. In the case of the second series of tests, the impact locations and velocities were predetermined by the project engineer in a letter dated October 7, 1985. This letter appears in the data section of this report.

3.0 TEST RESULTS

This test report covers two series of bird impact tests. The first series was conducted from 10/1/85 through 10/2/85. It consisted of two bird impacts on separate windshields mounted to the original test support structure used in all of the bird impact tests prior to this series of tests. The first impact (#213) was made at 352.8-knots with a 4.012-pound bird on windshield number 322-76 and was successful. The shot was made at a nominal 26°F on the outboard surface after a 15-minute soak period at 25°F. This soak period produced a temperature of 53°F on the inboard surface just prior to impact. The second shot (#214) was made at 345.8-knots with a 4.016-pound bird. This test proved to be a failure when a small plug was blown out of the impact area. Temperatures just prior to impact were -1°F on the outboard surface and 40°F on the inboard surface. The temperatures were established by soaking the windshield for 15-minutes at 0°F.

The second series of tests were conducted from 11/14/85 through 11/22/85 and were performed using a full size aircraft fuselage as the support structure for the test articles.

The first shot in this series (#221) was made on windshield number 322-80. The impact was conducted at room temperature with a 4.008-pound bird at a velocity of 393.6-knots and was successful. There was some minor bird penetration into the cockpit but that entered over the aft arch as it deflected during impact.

The second shot (#222) was made at an outboard surface temperature of 208°F and an inboard surface temperature of 159°F on transparency number 322-N. These temperature values were established after a 15-minute soak at 210°F was completed just prior to impact. The impact was made at 401.5-

knots with a 4.008-pound bird. The windshield passed the impact with only a few small cracks in the outboard ply. Aft arch deflection again allowed bird debris to enter the aircraft.

Shot #223 was conducted on windshield number 322-79, but at an ambient room temperature condition of 75°F. The test was made at 132.7-knots with a 4.012-pound bird in the same location as shot #222. Once more the windshield passed the test without any additional damage to the panel.

The fourth shot in this series (#224) was conducted at low temperature on windshield number 342-10 with a 4.010-pound bird at a velocity of 351.9-knots and good results. The test temperatures were 26°F on the outboard surface with an inboard surface temperature of 39°F. These values were reached after a 15-minute soak at 25°F. Post test evaluation revealed several large cracks in the P/C plies of the window.

Shot #225 was conducted on an instructor's window number 442-14 mounted in the fuselage as it would be in actual flight. The test impact was made at the center of the panel using a 4.010-pound bird at a velocity of 258.8-knots. The window passed the room temperature test without any major damage.

The sixth shot in this series (#226) was made at room temperature on windshield number 342-09. The impact occurred at a velocity of 398.9-knots with a 4.020-pound bird and proved to be a success. The nose impact produced a P/C crack that radiated from the impact position up to the aft arch.

Shot #227 was made as a second impact on windshield number 342-09. The impact location was changed from the nose position to the center line of the unit at the mid-point of the transparency. The impact was conducted at a room

temperature of 64°F with a 4.020-pound bird traveling at a velocity of 400.8-knots and was successful.

Shot #228 was made as the third impact on windshield number 342-09. It was performed at the port-sill location as defined in the original testing document. The impact was made at 400.2-knots with a 4.008-pound bird and again proved to be a success. The room temperature was 58°F at impact.

The final impact in this testing series (#229) was made on a second instructor's window number 442-15 in the port corner location. The room temperature impact (63°F) was conducted at a velocity of 259.3-knots with a 4.012-pound bird. The window cracked from the impact but bagged the bird allowing only a small amount of liquid residue to enter the aircraft structure.

Copies of the temperature data recorded on the hot and cold spots appears in the data section of this report.

APPENDIX I

DATA RECORDINGS

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: 322-81
SAMPLE IDENTIFICATION CODE: 322-76 CLASSIFICATION:
TEST DATE REQUESTED: 10-1-85 REQUESTED BY: J. W. Myers
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X Frame # 1368
PANEL CROSS SECTION:
5300 LINER .122 THICK
3/8 Poly
.060 112 PPG
3/16 Poly
8500 COATING

REF FIGURE 1 T-38 TEST PLAN - BIRD IMPACT. HEXCEL OUTBOARD AFT ARCH RETAINER

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES (X) NO ( )
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD		+ 53°F*
TEMPERATURE OUTBOARD	+ 25°F	+ 26°F*
BIRD WEIGHT (LBS)	4 lb	4.012
BIRD SPEED (KNOTS)	350 Kwots	351.8

AMBIENT TEMP: ___
IMPACT LOCATION: 9" Fwd of Aft Arch ℄
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: ___

REF FIG. 4 T-38 BIRD-IMPACT TEST PLAN

TEST RESULTS: SHOT NO: 213 TEST DATE: 10/1/85 TESTED BY: H.E.G.

WINDOW PASSED. SOME BIRD ENTERED COCKPIT OVER AFT ARCH DEFLECTION AND IMPACTED THE "PILOT" WITNESS PLATE. I/B POLY PLY DID NOT CRACK.

PPG WITNESS J. W. Myers CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

* AFTER 15 MINUTE SOAK AT 25°F.

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: 322-81
SAMPLE IDENTIFICATION CODE: 322-61 CLASSIFICATION:
TEST DATE REQUESTED: 10-1-85 REQUESTED BY: J.W. Myers
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X Frame # 1598
PANEL CROSS SECTION:
5300 LWER .057 THICK
3/8 Poly
.060 112 PPG
3/16 Poly
8500 COATING

REF FIGURE 1 T-38 TEST PLAN - BIRD IMPACT.
HEXCEL outboard AFT ARCH · RETAINER

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES (X) NO ( )
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD		+40°F *
TEMPERATURE OUTBOARD	0 °F	-1°F *
BIRD WEIGHT (LBS)	4 lb	4.016
BIRD SPEED (KNOTS)	350 Knots	345.8

AMBIENT TEMP: ___
IMPACT LOCATION: 9" Fwd of AFT Arch ℄
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: ___

REF FIG. 4 T-38 BIRD-IMPACT TEST PLAN

TEST RESULTS: SHOT NO: 214 TEST DATE: 10/2/85 TESTED BY: H.E.G.

WINDSHIELD FAILED. SMALL PLUG REMOVED. I/B PLY FRACTURED IN IMPACT AREA.

PPG WITNESS J.W. Myers CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

* AFTER 15 MINUTE SOAK AT 0°F

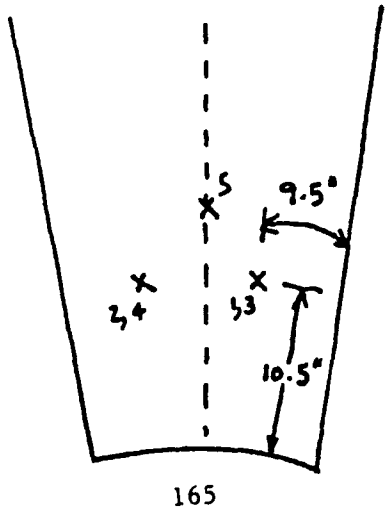
T-38 BIRD IMPACT

Shot #213 10/1/85

Time	TC#				
	1	2	3	4	5
8:53	29	28	68	68	61
8:56	22	25	62	64	60
8:59	23	23	59	59	61
9:02	25	26	55	56	60
9:05	25	26	53	53	60
9:06	Impact				

Shot #214 10/2/85

Time	TC#				
	1	2	3	4	5
8:49	42	41	76	82	57
8:51	23	28	80	82	52
8:53	12	16	77	78	57
8:55	6	9	72	73	60
8:57	-1	5	64	66	56
9:00	-1	2	58	59	54
9:03	-3	0	51	52	49
9:06	-3	0	45	46	60
9:09	-1	2	40	41	60
9:12	Impact				



Tc # 1 & 2 OUTBOARD
Tc # 3 & 4 INBOARD
Tc # 5 10" OFF I.B. SURFACE

Inter-Office Correspondence

Date: October 7, 1985

To: P. Walters
H. Goodrich

From: J. W. Myers

Location: Technology Development

Subject: T-38 Bird Impact Testing

Listed below is the proposed T-38 flight quality qualification impact testing that has been planned for the mid-November time frame. This shooting will all be done in the fuselage. At this time no Test Requests Forms have been included, due to the possibility of change before or during the testing. I will provide all the necessary request forms.

Shot Location	Temperature	Speed
Aft Arch Centerline	Ambient	400 and 130
Aft Arch Centerline	Hot (210°F)	400
Aft Arch Centerline	Cold (+25°F)	350 and 130
Nose	Ambient	400
Sill	Ambient	400
Location ? (Spare Unit)	?	?
Instructor Centerline	Ambient	250
Instructor Corner	Ambient	250

As discussed with Bob Pinnell, present plans are to start testing November 13th or 14th and continue into the week of November 18th till completed.

This should complete the contractual requirements for impact testing qualification. If you have any questions or need additional information, please contact me.

J. W. Myers
Project Engineer

dal

cc: W. Rothe
W. Heidish
S. Stewart
R. Cardno

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: WPAFB T-38 R+D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO 322-81
SAMPLE IDENTIFICATION CODE: 322-80 CLASSIFICATION:
TEST DATE REQUESTED: Nov 14, 1985 REQUESTED BY: D. Stewart
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED OTHER
MOUNTING FRAME: RIGID FLEXIBLE OTHER X Aircraft Fuselage
PANEL CROSS SECTION:

5300 Liner
3/8 Poly
.060 PPG 112
3/16 Poly
8500 coating

Frame #1601
Reinforcement # UDRI-9
Ref. Figure 1 T-38 Test Plan - Bird Impact
Nexcel Aft Arch outboard retainer

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES ( ) NO (X)
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	Ambient	73°F
TEMPERATURE OUTBOARD	Ambient	73°F
BIRD WEIGHT (LBS)	4.0 lbs	4.008
BIRD SPEED (KNOTS)	400 kts	393.6

AMBIENT TEMP:
IMPACT LOCATION: 9" Fwd of Aft Arch CL
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: —

TEST RESULTS: SHOT NO: 221 TEST DATE: 11/14/85 TESTED BY: L.E.G.

W/S PASSED. CRACKS IN O.B. POLY PLY. I.B. PLY INTACT.
MINOR BIRD PENETRATION OVER THE ART ARCH DEFLECTION.

PPG WITNESS D. Stewart CUSTOMER WITNESS

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: WPAFB T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO 322-81
SAMPLE IDENTIFICATION CODE: 322-79 CLASSIFICATION:
TEST DATE REQUESTED: Nov 1985 REQUESTED BY: A. Stewart
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED OTHER
MOUNTING FRAME: RIGID FLEXIBLE OTHER X Aircraft Fuselage
PANEL CROSS SECTION:

5300 Liner
3/8 Poly
.060 PPG 112
3/16 Poly
8500 Coating

Frame # 1598 (rebuilt)
Reinforcement # UDRI-11
Ref Figure 1 T-38 Test Plan - Bird Impact
Hexcel Aft Arch outboard retainer

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES (X) NO ( )
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	—	159°F *
TEMPERATURE OUTBOARD	+210 °F	208°F *
BIRD WEIGHT (LBS)	4.0 lbs.	4.008
BIRD SPEED (KNOTS)	400 kts	401.5

AMBIENT TEMP:
IMPACT LOCATION: 9" Fwd of Aft Arch CL
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: —

TEST RESULTS: SHOT NO: 222 TEST DATE: 11-15-85 TESTED BY: H.E.G.

W/S PASSED. FEW SMALL P/C CRACKS IN O.B. PLY. LARGE AMOUNT OF BIRD DEBRIS IN COCKPIT. APPARENTLY ENTERS OVER AFT ARCH DEFLECTION.

PPG WITNESS Norman D. Stewart CUSTOMER WITNESS

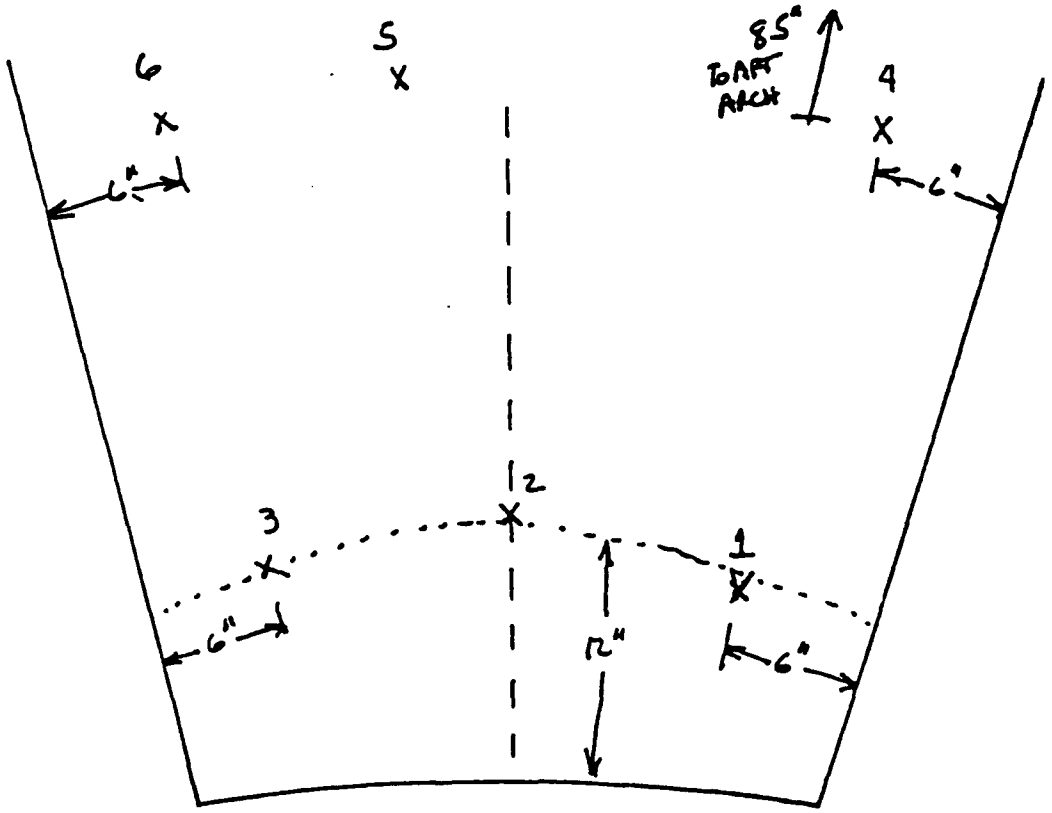
DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

* AFTER 15 MINUTE SOAK AT 210°F

T-38 BIRD IMPACT

Shot #222 11/15/85

Time	TC#							
	1	2	3	4	5	6	7	8
11:06	78	78	78	79	78	79	78	78
11:09	82	84	83	98	92	88	78	78
11:12	93	94	95	100	98	94	78	78
11:15	104	103	105	102	101	96	78	79
11:18	118	115	118	115	111	105	84	80
11:21	132	129	136	133	129	123	89	80
11:24	140	138	144	141	145	135	94	82
11:27	152	156	154	148	168	147	101	83
11:30	157	167	159	152	178	157	108	85
11:33	168	176	168	168	190	173	117	87
11:36	178	192	199	185	209	188	124	89
11:38	186	202	203	191	213	194	130	90
11:42	196	210	212	193	212	195	140	93
11:45	204	214	216	194	211	196	147	94
11:48	203	212	213	196	212	196	152	95
11:51	202	209	211	200	214	198	157	96
11:52	199	208	207	200	212	198	159	97
11:53	Impact							



PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: WPAFB T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO 322-81
SAMPLE IDENTIFICATION CODE: 322-79 CLASSIFICATION:
TEST DATE REQUESTED: Nov 1985 REQUESTED BY: H. Stewart
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X Aircraft Fuselage
PANEL CROSS SECTION:

5300 Liner
3/8 Poly
.060 PPG 112
3/16 Poly
8500 Coating

Frame #
Reinforcement #
Ref Figure 1 T-38 Test Plan - Bird Impact
Hexcel Aft Arch outboard retainer

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES ( ) NO (X)
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	Ambient	75°F
TEMPERATURE OUTBOARD	Ambient	75°F
BIRD WEIGHT (LBS)	4.0 lbs.	4.012
BIRD SPEED (KNOTS)	135 kts	132.7

AMBIENT TEMP: ___
IMPACT LOCATION: 9" Fwd of Aft Arch CL
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: —

TEST RESULTS: SHOT NO: 223 TEST DATE: 11-15-85 TESTED BY: H.E.G.

W/S PASSED. PREVIOUS SHOT CRACKS DID NOT PROPAGATE.
CANOPY BLOWN OUT WITH BIRD RESIDUE.

PPG WITNESS Herman D. Stewart CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: WPAFB T-38 R4D Contract F33615-81-C-3403
NP NUMBER: 156501 CHARGE TO: WO 322-81
SAMPLE IDENTIFICATION CODE: 342-10 CLASSIFICATION:
TEST DATE REQUESTED: Nov 1985 REQUESTED BY: H. Stewart
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X Aircraft Fuselage
PANEL CROSS SECTION:

5300 Liner
3/8 Poly
.060 PPG 112
3/16 Poly
8500 Coating

Frame #1368 (rebuilt)
Reinforcement # UDRI-12
Ref Figure 1 T-38 Test Plan - Bird Impact
Hexcel Aft Arch outboard retainer

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES (X) NO ( )
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	—	39°F *
TEMPERATURE OUTBOARD	+25°F	26°F *
BIRD WEIGHT (LBS)	4.0 lbs.	4.010
BIRD SPEED (KNOTS)	350 kts.	351.9

AMBIENT TEMP: ___
IMPACT LOCATION: 9" Fwd of Aft Arch CL
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: —

TEST RESULTS: SHOT NO: 224 TEST DATE: 11-18-85 TESTED BY: H.E.G.

WS PASSED. LARGE NUMBER OF CRACKS IN PC. MINIMAL AMOUNT OF BIRD RESIDUE IN COCKPIT OVER AFT ARCH.

PPG WITNESS Herman O. Stewart CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

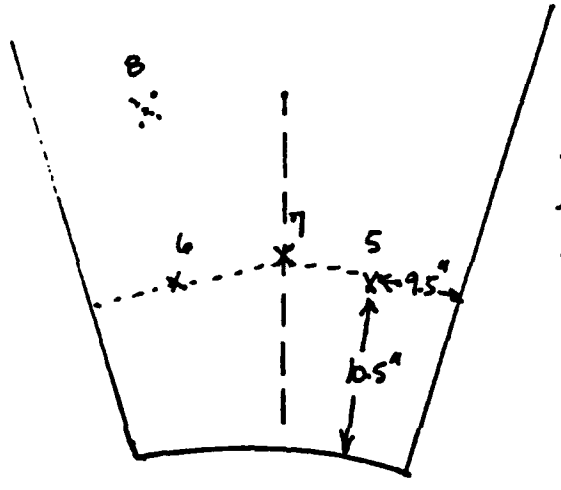
* AFTER 15 MINUTE SOAK AT 25°F

T-38 BIRD IMPACT

Shot #224

11/18/85

Time	TC#			
	5	6	7	8
12:32	53	52	51	58
12:34	37	36	51	48
12:36	28	26	51	44
12:38	26	25	49	43
12:40	26	25	47	42
12:42	25	25	45	43
12:44	26	25	43	41
12:46	25	25	42	41
12:48	26	25	41	42
12:50	26	25	39	42
12:51	26	26	39	42
12:52	Impact			



Tc # 5 & 6 O.B. SURFACE
Tc # 7 I.B. SURFACE
Tc # 8 10° OFF I.B. SURF.

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: T-38 R&D Contract F 33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: 322-81
SAMPLE IDENTIFICATION CODE: 442-14 CLASSIFICATION:
TEST DATE REQUESTED: Nov 1985 REQUESTED BY: J.W. Myers
PANEL TYPE: FULL SIZE X 26"x26" ___ BOLTED X CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X AIRCRAFT FUSELAGE FRAME NO. 785
PANEL CROSS SECTION:

8500 COATING
1/4 Poly
.060 PPG-112
3/16 Poly
8500 COATING

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES ( ) NO (X)
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	Ambient	71°F
TEMPERATURE OUTBOARD	Ambient	71°F
BIRD WEIGHT (LBS)	4lbs	4.010
BIRD SPEED (KNOTS)	250 KTS.	258.8

AMBIENT TEMP: ___
IMPACT LOCATION: Center Centerline
INSTALLATION ANGLE: 70°
SWEEP-BACK ANGLE: —

TEST RESULTS: SHOT NO: 225 TEST DATE: 11/19/85 TESTED BY: H.E.G.

Window PASSED.

PPG WITNESS J.W. Myers CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: WPAFB T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO 322-81
SAMPLE IDENTIFICATION CODE: 342-09 CLASSIFICATION:
TEST DATE REQUESTED: Nov, 1985 REQUESTED BY: A. Stewart
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X Aircraft Fuselage
PANEL CROSS SECTION:

5300 Liner
3/8 Poly
.060 PPG 112
3/16 Poly
8500 Coating

Frame #1570 (rebuilt)
Reinforcement # UDRI-13
Ref Figure 1 T-38 Test Plan - Bird Impact
Hexcel Aft Arch outboard retainer

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES ( ) NO (X)
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	Ambient	62°F
TEMPERATURE OUTBOARD	Ambient	62°F
BIRD WEIGHT (LBS)	4.0 lbs.	4.020
BIRD SPEED (KNOTS)	400 kts.	398.9

AMBIENT TEMP: ___
IMPACT LOCATION: 6" Aft of Nose CL
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: —

TEST RESULTS: SHOT NO: 226 TEST DATE: 11-21-85 TESTED BY: H.E.G.

W/S PASSED. LARGE P/C CRACK RADIATING FROM IMPACT POINT UP TO AFT ARCH.

PPG WITNESS Norman D. Stewart CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: WPAFB T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO 322-81
SAMPLE IDENTIFICATION CODE: 342-09 CLASSIFICATION:
TEST DATE REQUESTED: Nov 1983 REQUESTED BY: A. Stewart
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X Aircraft Fuselage
PANEL CROSS SECTION:

5300 Liner
3/8 Poly
.060 PPG 112
3/16 Poly
8500 Coating

Frame # 1570 (rebuilt)
Reinforcement # UDRI-13
Ref Figure 1 T-38 Test Plan - Bird Impact
Hexcel Aft Arch outboard retainer

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES ( ) NO (X)
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	Ambient	64°F
TEMPERATURE OUTBOARD	Ambient	64°F
BIRD WEIGHT (LBS).	4.0 lbs.	4.020
BIRD SPEED (KNOTS)	400 kts.	400.8

AMBIENT TEMP: ___
IMPACT LOCATION: w/s Center CL
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: —

S/N 342-09 SHOT #2

TEST RESULTS: SHOT NO: 227 TEST DATE: 11-21-85 TESTED BY: H.E.G.

W/S PASSED. SOME ADDITIONAL CRACKS.

PPG WITNESS Norman O. Stewart CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: WPAFB T-38 R&D Contract F33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: WO 322-81
SAMPLE IDENTIFICATION CODE: 342-09 CLASSIFICATION:
TEST DATE REQUESTED: Nov 1985 REQUESTED BY: S. Stewart
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED ___ OTHER ___
MOUNTING FRAME: RIGID ___ FLEXIBLE ___ OTHER X Aircraft Fuselage
PANEL CROSS SECTION:

5300 Liner
3/8 Poly
.060 PPG 112
3/16 Poly
8500 Coating

Frame # 1570 (rebuilt)
Reinforcement # UDRI-13
Ref Figure 1 T-38 Test Plan - Bird Impact
Hexcel Aft Arch outboard retainer

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES ( ) NO (X)
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	Ambient	58°F
TEMPERATURE OUTBOARD	Ambient	58°F
BIRD WEIGHT (LBS)	4.0 lbs.	4.008
BIRD SPEED (KNOTS)	400 kts.	400.2

AMBIENT TEMP: ___
IMPACT LOCATION: Port sill Corner 3" x 10" aLo
INSTALLATION ANGLE: 27.5°
SWEEP-BACK ANGLE: —

S/N 342-09 SHOT #3

TEST RESULTS: SHOT NO: 228 TEST DATE: 11-21-85 TESTED BY: H.E.G.

W/S PASSED. NO ADDITIONAL APPARENT DAMAGE.

PPG WITNESS Norman D. Stewart CUSTOMER WITNESS ___

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

PPG INDUSTRIES - BIRD IMPACT TEST REQUEST

TEST PROGRAM: T-38 R&D Contract F-33615-81-C-3403
NP NUMBER: 158501 CHARGE TO: 322-81
SAMPLE IDENTIFICATION CODE: 442-15 CLASSIFICATION:
TEST DATE REQUESTED: Nov 1985 REQUESTED BY: J.W. Myers
PANEL TYPE: FULL SIZE X 26"x26" BOLTED X CLAMPED OTHER
MOUNTING FRAME: RIGID FLEXIBLE OTHER X Aircraft Fuselage Frame No 7858
PANEL CROSS SECTION:

8500 Coating
1/4 Poly
.060 PPG-112
3/16 Poly
8500 Coating

Ref Fig. 6 Test Plan - Bird Impact T-38

HIGH SPEED FILM: YES (X) NO ( ) THERMOCOUPLES YES ( ) NO (X)
STILL PHOTOS: YES (X) NO ( ) STRAIN GAGES (FOUR ONLY) YES ( ) NO (X)
CHICKEN (X) GEL PACK ( ) ATTACH LOCATION SKETCH AND NUMBER

TEST CONDITIONS	REQUESTED	ACTUAL
TEMPERATURE INBOARD	Ambient	63°F
TEMPERATURE OUTBOARD	Ambient	63°F
BIRD WEIGHT (LBS)	4 lbs	4.012
BIRD SPEED (KNOTS)	250 kts.	259.3

AMBIENT TEMP:
IMPACT LOCATION: Port Corner
INSTALLATION ANGLE: 70°
SWEEP-BACK ANGLE: —

TEST RESULTS: SHOT NO: 229 TEST DATE: 11/22/85 TESTED BY: H.E.G.

Panel cracked but bagged the bird. Small amount of liquid residue entered the cockpit.

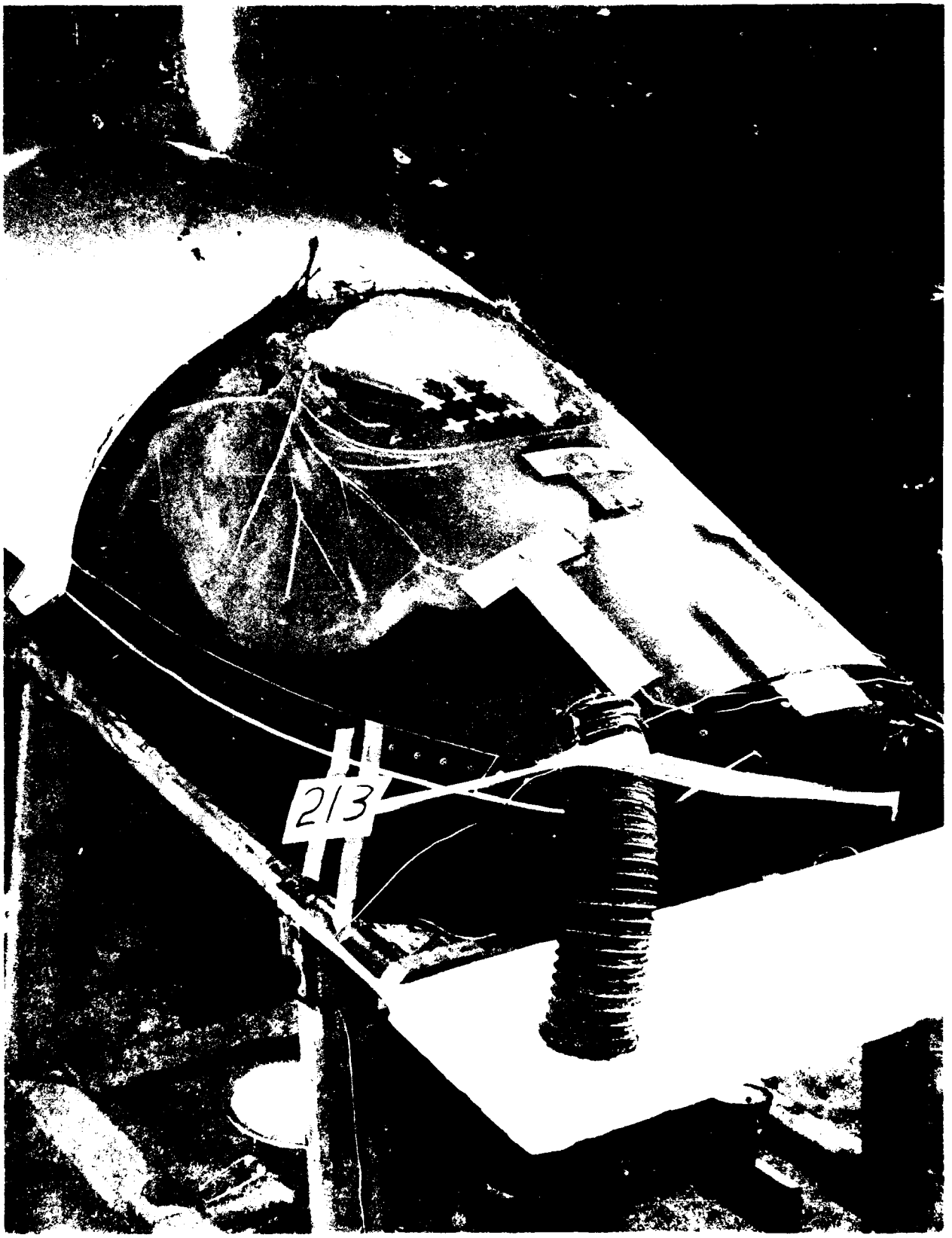
PPG WITNESS J.W. Myers CUSTOMER WITNESS

DISTRIBUTION BEFORE TEST: H. GOODRICH, P. WALTERS, ORIGINATOR
DISTRIBUTION AFTER TEST: ORIGINATOR, FILE, H. GOODRICH

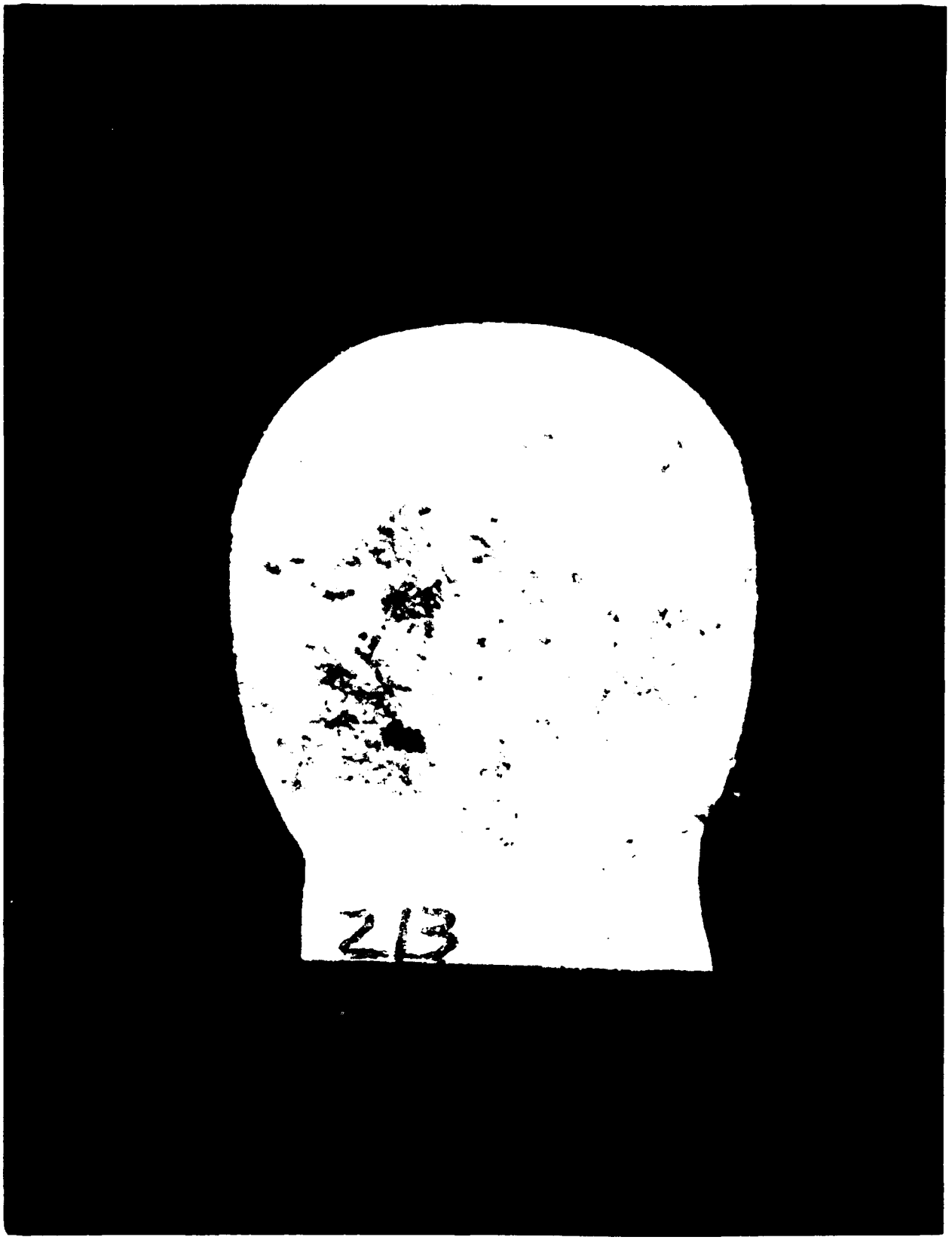
APPENDIX II

PHOTOGRAPHS

PHOTOGRAPH #1
COLD SHOT #213
TEST SET UP



PHOTOGRAPH #2
COLD SHOT #213
POST TEST



PHOTOGRAPH #3
COLD SHOT #213
WITNESS PLATE

PHOTOGRAPH #4
COLD SHOT #214
POST TEST

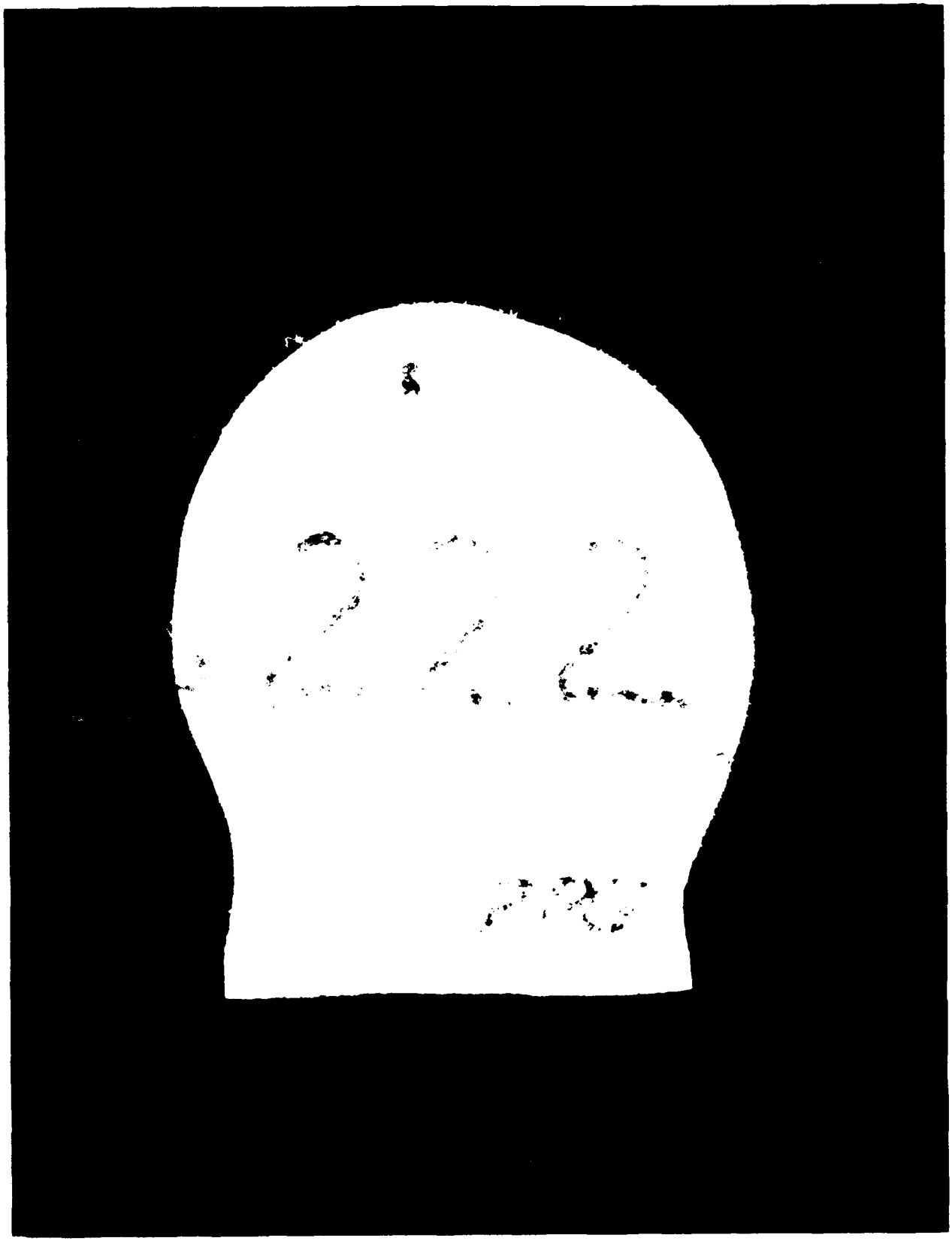
PHOTOGRAPH #7
SHOT #221
POST TEST

PHOTOGRAPH #6
SHOT #221
FUSELAGE SET UP

PHOTOGRAPH #8
HOT SHOT #222
TEST SET UP

PHOTOGRAPH #9
HOT SHOT #222
POST TEST

PHOTOGRAPH #10
SHOT #223
POST TEST

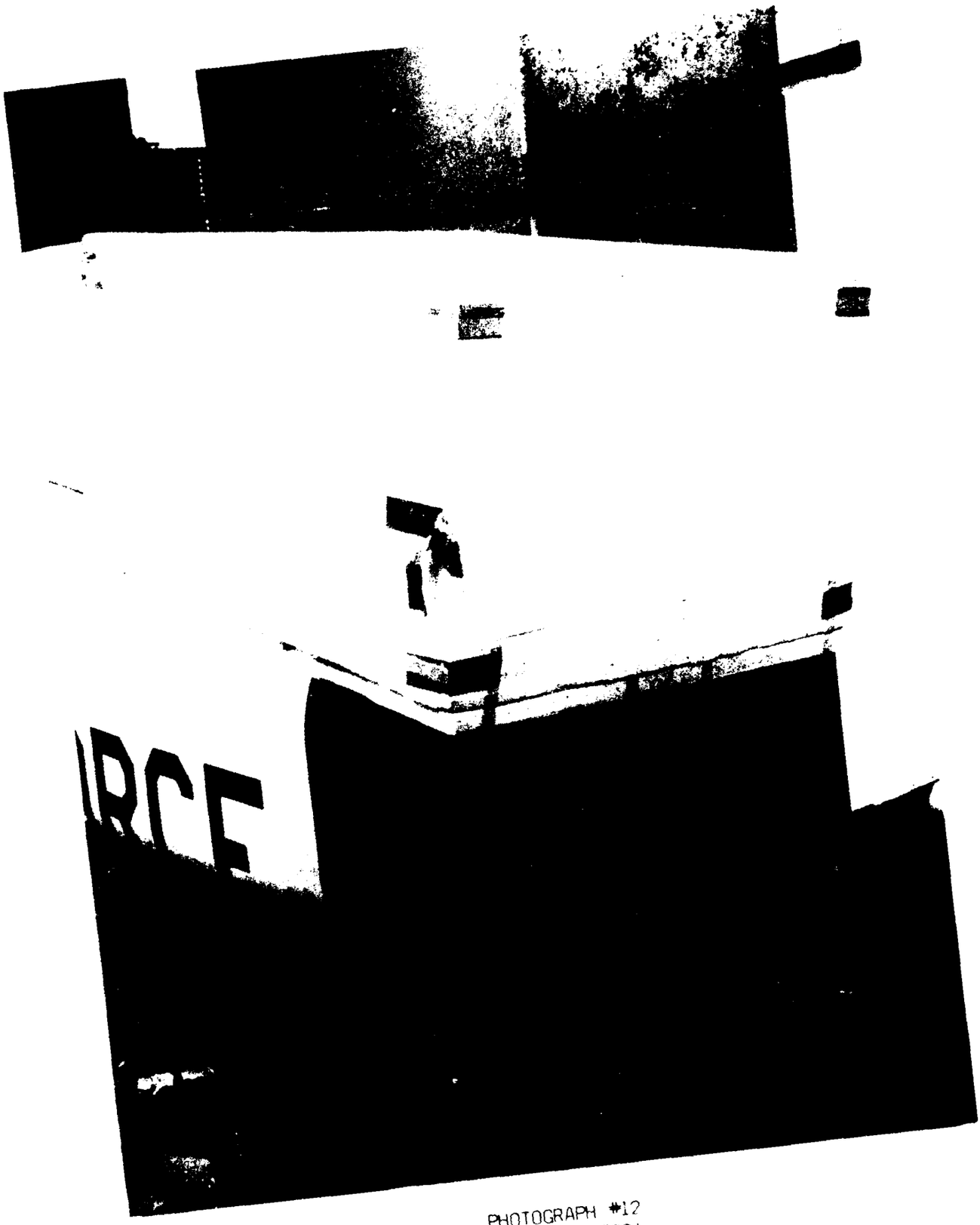


PHOTOGRAPH #11
SHOT #222 AND #223
WITNESS PLATE

PHOTOGRAPH #13
COLD SHOT #224
POST TEST

PHOTOGRAPH #14
SHOT #225
INSTRUCTOR WINDOW
POST TEST

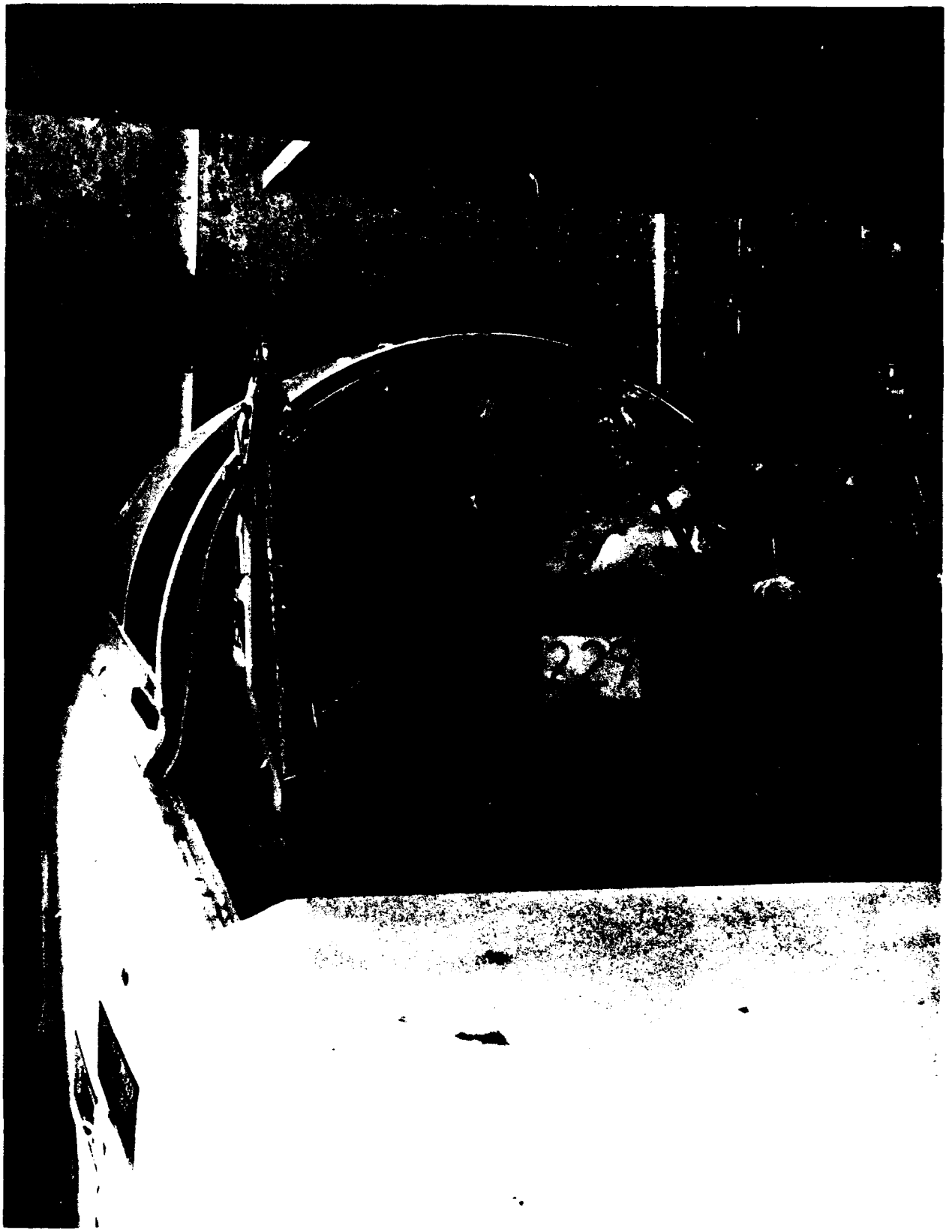
PHOTOGRAPH #15
SHOT #226
POST TEST



PHOTOGRAPH #12
COLD SHOT #224
FUSELAGE SET UP

PHOTOGRAPH #16
SHOT #227
POST TEST

PHOTOGRAPH #17
SHOT #228
POST TEST



PHOTOGRAPH #18
SHOT #229
POST TEST

APPENDIX D

T-38 BIRD IMPACT RESISTANT WINDSCREEN OT & E AIRCRAFT

TABLE OF CONTENTS

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS SAN ANTONIO AIR LOGISTICS CENTER (AFLC)
KELLY AIR FORCE BASE, TEXAS 78241-5000

JUL 23 1988

REPLY TO ATTN OF: MMSRA

SUBJECT: T-38 Bird Impact Resistant Windscreen OT&E Aircraft

TO: See Distribution List

1. This package is designed to assist you in the maintenance of your new windscreen. It contains pertinent information about cleaning, removal and installation of your windscreen. Please inspect your aircraft's form 95 for any clearances or problems particular to your assemblies. Any questions you have that are not covered by the information in this package should be addressed to SA-ALC/MMSRA.

2. The coating on the transparency is scratch resistant and will heal itself of superficial marks. For example, if the windscreen is covered overnight by a transparency, cover marks from the folds of the material may appear in warm temperatures. If the transparency is exposed to direct sunlight for a short period of time these will disappear. No abrasive material should be used to remove marks. This will only destroy the coating. Any marks that do not go away when using the appropriate cleaning instructions should be referred to SA-ALC/MMSRA.

3. When removing, installing or just lifting the forward windshield by removing piano hinge pins, a pipe clamp should be used to maintain the distance across the aft arch. Instructions are included in this package. Do not use masking tape, bullhide or any adhesive material on the surfaces of the transparency. This will damage the surface coating and leave marks that impair the optical quality of the windscreen. It may be covered with soft cloth taped to the frame.

4. The reporting forms will be used to help us evaluate the windscreens performance. You are free to add additional comments that may aid in the evaluation. We appreciate your timely completion and submission of the forms. They should be compiled and sent every 30 days to SA-ALC/MMSRA, Kelly AFB TX 78241-5000, ATTN: Lt Janaine Boskovich.

5. We have also included a sign that should be placed on the glare shield when the aircraft is not in flight. It may be stored in the map case or wherever you find appropriate. This

should become a part of the routine when leaving the airplane to warn those who may not recognize the windscreen of its special cleaning procedures.

6. Point of contact Lt Janaine Boskovich/MMSRA/Autovon 945-7561.

LESLIE DAVIS
Chief, Fighter/TAC/TRN SECT.
System Management Division

5 Atch
1. Distribution List
2. Reporting Forms
3. Cleaning Instructions
4. Removal Procedures
5. Warning Sign

cc: HQ ATC LGM/SEF

Distribution List

71FTW/DOV/MAQ (Acft 62-3721)
Vance AFB OK

12FTW/POV/MAQ (Acft 66-8402)
Randolph AFB TX

47FTW/DOV/MAQ (Acft 64-13251)
Laughlin AFB TX

14FTW/DOV/MAQ (Acft 61-0849)
Columbus AFB MS

82FTW/DOV/MAQ (Acft 62-3616)
Williams AFB AZ

64FTW/DOV/MAQ (Acft 62-3681)
Reese AFB TX

80FTW/DOV/MAQ (Acft 62-3750)
Sheppard AFB TX

ATTACHMENT I

REPORTING FORM

1.1 This form is to be used to report maintenance actions involving the test windshields. This form should be completed and sent to SA-ALC/MMSRA every month. Dates and location for aircraft TDY should be noted on the reverse side.

1.2 Part I: Self explanatory.

1.3 Part II: Can be obtained from standard maintenance documentation. Include routine and non-routine actions. State any deviation from special cleaning procedures.

T-33 WINDSHIELD MAINTENANCE REPORT

PART I: IDENTIFICATION AND LOCATION	
AIRCRAFT TAIL NUMBER:	DATE:
BASE/LOCATION:	
HOURS FLYING FOR REPORT PERIOD	

PART II: MAINTENANCE RECORD			
DATE DISC	DISCREPANCY	CORRECTIVE ACTION	CLOCK HRS/ MANHOURS

2.1 This form is to be completed by the unit project officer on a monthly basis for the ground weather conditions that aircraft are exposed to. Normally, only one form set per month will be required. Additional forms may be required if the test aircraft are deployed to other bases and all of the information cannot be entered in a meaningful manner.

2.2 Date: Self explanatory

2.3 Temperature: F

2.4 Wind: Record the average speed for the day and maximum qusts.

2.5 % RH: Record the average relative humidity for the day.

2.6 Conditions: Record the conditions for precipitation, cloud cover, pollution index, etc.

T-38 WINDSHIELD DURABILITY PROGRAM

WEATHER CONDITIONS REPORT

Aircraft Tail Numbers _____, _____, _____, _____

DATE	TEMP HI	TEMP LO	WIND AVERAGE GUSTS	RH %	CONDITIONS

3.1 This form is to be completed by an aircrew member upon the completion of each flight in an aircraft fitted with bird impact resistant windshields.

3.2 Part I: Self Explanatory

3.3 Part II:

A. Conditions and Duration: Check appropriate block(s) to indicate the conditions encountered during flight and record the approximate total duration (in minutes).

B. Flight Profile: Briefly describe the flight airspeeds and altitudes vs time of flight profiles. It is anticipated that each unit will have standard or typical mission identifier may be assigned with the identifier used after the first explanation. Example: If all low level radar missions are flown following similar airspeed and altitude profiles then these profiles would be submitted one-time with a suitable identifier such as "LLR" then only "LLR" need be entered on the form for subsequent missions.

3.4 Part III: Windshields Comparison: Compare the test windshields just flown to the currently used T-38 windshields and record relative merit with respect to the optical characteristics listed. Base the comparison on past experience and the windshield optical characteristics observed during this flight. Record the comparison by checking the appropriate boxes.

3.5 Part IV: Comments: Self Explanatory.

T-33 Windshield Aircrew Debriefing Report

Part I: AIRCRAFT TAIL NUMBER: Date:

Take off Time: Land Time:

Crew Member

Part II: A. CONDITIONS Duration (Min)

Rain Lt ( ) Med ( ) Heavy ( ) _____

Sleet Lt ( ) Med ( ) Heavy ( ) _____

Snow Lt (—) Med ( ) Heavy ( ) _____

Clouds Lt ( ) Med ( ) Heavy ( ) _____

Below 2000 FTAGL ( ) _____

Blowing Dust/Sand ( ) _____

Other ( ) (Specify _____

B. FLIGHT PROFILE

Part III: WINDSHIELD COMPARISON

	Distortion	Multiple Images	Reflections	Haze	Overall Comparison
Much Better					
Better					
Same					
Worse					
Much Worse					

Part IV: COMMENTS (Continue on Reverse if Needed).

CLEANING AND DE-ICING INSTRUCTIONS

1.0 SPECIAL INSTRUCTIONS

1.1 Remove rings, watches, and bracelets. Do not let zippers, belt buckles, etc., contact the transparency.

1.2 Do not clean the transparencies with a dry cloth or dry paper.

1.3 Never clean with abrasive wipers such as ordinary paper towels.

1.4 Never use masking tape or bullhide on the transparency.

1.5 Do not use extreme pressure or mechanical tools (buffing wheels) for cleaning.

2.0 MATERIALS, TOOLS, EQUIPMENT

2.1 Lint free optic cloth wipers, Kaydry, chamois, cotton cloth CCC-C-458, flannel cloth or equivalent.

2.2 Cleaning solution made up of 80% distilled water, 18% Isopropanol, and 2% Dawn liquid soap or equivalent (by volume). Distilled water is preferred but tap water may be substituted if it appears clean of abrasives.

2.3 50/50 Isopropanol/water solution.

3.0 PROCEDURE

3.1 Clean outboard surface with cloth (Section 2.1) soaked in cleaning solution (Section 2.2). Wipe off excess with gentle strokes using dry lint free cloth (Section 2.1).

3.2 Clean again with 50/50 Isopropanol/water cleaning solution and cloth (Section 2.1) to guarantee removal of all cleaning solution. Wipe off excess with gentle strokes using lint free cloth (Section 2.1).

3.3 Inspect and re-clean as required.

3.4 Repeat 3.1, 3.2, and 3.3 on inboard surface.

4.0 DE-ICING PROCEDURE

4.1 De-icing fluids may be used on the transparency and then wipe with a cotton cloth.

4.2 Do not scrape the transparency.

INSTALLATION, REMOVAL AND LIFTING PROCEDURES

Follow all T.O. 1T-38A-2-2 installation procedures for the forward windshield frame with these precautions:

1. Before attempting to install hinge pins or aft retaining bolts in bottom of frame check to see if hinge nodes line up on both sides. If the nodes are wider than the fuselage obtain a pipe clamp approximately 36" in length. Use the clamp on the aft frame ledge approximately 5" up from the longeron. The frame should be protected by masking tape in the area where the clamp makes contact. Pull the frame in until the nodes on the hinge line-up. Insert the aft retaining bolts and then insert the hinge pin rods. Remove the clamp after tightening the aft retaining bolts.

2. For removal or lifting the pipe clamp should be placed in the same position as noted above for installation. Before attempting to remove the hinge pin rods or retaining bolts, apply pressure on the pipe clamp then remove bolts and pins. The pressure on the pipe clamp should be applied in such a manner that it gently maintains the distance across the aft arch, keeping it from spreading when removing the hinge pins. This pressure should not be so great as to deform the frame. Release pressure on clamp slowly.

CAUTION:

Do not mask transparency with tape or any adhesive type covering.

Allow proper 24 hour cure time for all sealants.

APPENDIX E

PILOT's RATING AND COMMENTS FOR EACH INDIVIDUAL BASE

WILLIAMS TAIL#3616

		T-38 DEBRIEFING SUMMARY TAIL# 3616			
WILLIAMS AFB					
	DATE	NOV DEC JAN FEB MAR			
		APR MAY JUN JUL			
TOTAL FLIGHT TIME HRS:		267.45			
		COMPARISON			
		MULTIPLE			
	DISTORTION	IMAGES	REFLECTIONS	HAZE	OVERALL
MUCH BETTER	1	1	4	4	0
BETTER	9	8	30	27	10
SAME	90	248	199	171	101
WORSE	154	36	61	92	144
MUCH WORSE	78	34	34	31	75
TOTAL NUMBER OF REPORTS		330			

COMMENTS
WINDSCREEN APPEARS TO BE SLIGHTLY TINTED
THE CANOPY FRONT IS THICKER- MAKING BACK SEAT LANDINGS MORE DIFFICULT
SLIGHT DISTORTIONS WHERE THE CANOPY MEETS THE GLARESHIELD
NO DIFFERENCE OTHER THAN THE TINTING
BACK SEAT HAS GREATER DISTORTION ESPECIALLY NEAR THE SIDES MAKING BACK SEAT APPROACHES
MORE DIFFICULT-UNUSUAL COLORS ARE QUITE NOTICEABLE ESPECIALLY GOING THROUGH CLOUDS
CANOPY BRACE IS THICK-LIMITS VISION SLIGHTLY
CANOPY BOW IS THICK WHICH RESULTS IN MORE RESTRICTED VIEW
SIGNIFICANT REDUCTION OF FORWARD VISIBILITY FROM REAR COCKPIT
THICKER SO MAKES BACK SEAT LANDING THOUGHER
LARGER FRONT COCKPIT CANOPY BOW CUTS DOWN FORWARD VISION FROM REAR SEAT A LITTLE
THICKNESS OF CANOPY BOW AND DIFFERENT MAG COMPASS MOUNT MAKES VISIBILITY FROM
REAR COCKPIT DURING STRAIGHT INS DIFFICULT(I.E. NO FLAPS)
AS A FORMATION SHIP IT IS DIFFICULT TO GET A CLEAR PICTURE OF LEAD ON TURING REJOINS
DUE TO A SMALL BIT OF DISTORTION IN THE FRONT CORNERS OF THE FRONT WINDSCREEN
AS THE OUTSIDE TEMPERATURE WENT DOWN-THE WINDSCREEN TENDED TO POLARIZE SIGNIFICANTLY
TO THE POINT WHERE IT WAS DIFFICULT TO SEE SMALL OBJECTS(AIRCRAFT TRAFFIC)
FORMATION SHIP HARD TO GET A CLEAR PICTURE OF LEAD
DURING LANDING PHASE DIFFICULT TO SEE OVERRUN FROM BACK SEAT IT APPEARS BLURRY-
MAKING DEPTH PRECEPTION DIFFICULT
VISION FROM BACK SEAT: THE CANOPY BOW IS THICKER AND MAG. COMPASS MOUNT BIGGER
RESULT--WORSE VISION FROM REAR
DISTORTION FROM REAR COCKPIT DIT NOT AFFECT FLYING TRAFFIC PATTERNS AND LANDINGS
DON'T THINK THERE'S ANYTHING WRONG WITH CANOPY-IT'S JUST THAT WE'RE NOT USE TO IT
CANOPY BOW TO THICK- CHANGES AIM POINT
CANOPY BOW TO THICK AND THROWS OFF USUAL AIM POINT-CUTS DOWN CLEARING--
DO NOT RECOMMEND THIS JET FOR INITIAL SOLOS
THICKER CANOPY REDUCES REAR COCKPIT FORWARD VISIBILITY SIGNIFICANTLY
DEPTH PERCEPTION IS VERY BAD
DISTORTION ON LANDING-LESS VISION FORWARD FROM REAR COCKPIT
VISIBILITY VERY POOR FROM REAR COCKPIT
CANOPY BOW IS TOO THICK-IMPAIRS BACK SEAT VISION
CANOPY BOW IS TOO WIDE
FROM REAR COCKPIT STRAIGHT LINES APPEAR TO BEND
COULD SEE LINES DISTORT IN REAR COCKPIT
REAR-- REDUCED VISIBILITY
NOTICEABLE DISTORTION ONLY PRESENT AT BOTTOM EDGES OF WINDSCREEN--
WIDER CANOPY BOW ALSO OBSCURES NOTICEABLY MORE AREA
DISTORTION IS MAINLY AROUND BOTTOM OF THE WINDSCREEN
THICK CANOPY BOW CAUSES VISIBILITY PROBLEMS AND SOME DISTORTION
REAR COCKPIT AND FRONT COCKPIT-NEW CANOPY BOW SEVERELY RESTRICTS FORWARD
VISIBILITY ESPECIALLY IN FORMATION
POOR VISIBILITY FROM BACK SEAT-DISTORTION MAKES A/C LOOK HIGHER THAN ACTUAL
THE ONLY REAL PROBLEM WITH THE CANOPY IS THE LOSS OF FORWARD VISIBILITY DUE TO THE WIDER
CANOPY RAIL--REAR COCKPIT-THE NEW CANOPY GREATLY DECREASES THE FORWARD
VISIBILITY BECAUSE OF THE LARGER CANOPY RAIL
FRONT: GLARE WAS A PROBLEM OVERALL AND ALSO WITH PRISM EFFECT IN LOWER FRONT AND
AROUND SIDES OF WINDSCREEN--REAR: 60% REDUCTION IN FORWARD VISION DUE CANOPY BOW
RAINBOW AND GLARE WHEN POINTED INTO SUN REDUCED FORWARD VISION FURTHER
VISION FROM BACK SEAT: THE CANOPY BOW IS THICKER AND MAG COMPASS MOUNT IS BIGGER
RESULT--WORSE VISION FROM BACK

DISTORTION FROM REAR COCKPIT DID NOT AFFECT FLYING TRAFFIC PATTERNS AND LANDINGS
REDUCES VISIBILITY FROM BACK SEAT FOR LANDING-NOT A GOOD TREND IN A TRAINER-DID NOT
NOTICE TILL LANDING PHASE-SLIGHTLY CHANGES PICTURE(LIMIT TO POST CONTACT CHECK STUDENTS
GOOD CLARITY-BUT LOSS OF VISION DUE TO WIDER CANOPY RAIL
FRONT COCKPIT MUST LEAN FORWARD TO LOOK STRAIGHT AHEAD
DEPTH PERCEPTION IS DECREASED DUE TO DISTORTION AND REFLECTIONS--VISIBILITY IS
DECREASED DUE TO ENLARGED CANOPY BOW AND PLACEMENT OF MAG COMPASS
VERY RESTRICTIVE FLYING FORMATION OFF OF OTHER A/C-DISTORTION ALONG OUTER EDGES
ONLY REASON IT'S WORSE IS ON NO FLAP LANDINGS WHERE DISTORTION IS A BIG FACTOR
OVERALL WINDSHIELD RATES THE SAME-HOWEVER FOR SAFETY REASONS IT IS MUCH PREFERRED
DISTORTION OCCURS LOOKING THROUGH LOWER PARTS OF WINDSHIELD DURING NO FLAP LANDINGS
BACK SEAT LANDINGS ARE SPORTY-CANOPY BOW IS MUCH LARGER THAN OTHER WINDSHIELDS
WHICH CUTS DOWN ON VISIBILITY AND WHAT YOU SEE-DISTORTIONS ARE MUCH WORSE ALSO
REAR COCKPIT VISIBILITY REDUCED BY EXTRA WIDE CANOPY-FRONT COCKPIT: THE DISTORTION
WAS ONLY IN LOWER 1/3 OF THE FRONT WINDSCREEN
EXTRA LARGE CANOPY BOW MADE REAR COCKPIT LANDINGS MORE DIFFICULT
TEND TO MAKE YOU THINK THAT YOU ARE CLOSER TO GROUND-MAKES YOU FLARE HIGHER
VISIBILITY IS SO RESTRICTED-ESPECIALLY FOR THE REAR COCKPIT-THAT THERE IS NO WAY
THIS WINDSCREEN CAN BE RATED THE SAME AS THE OLD ONES
CLOSE TO THE GROUND IT BECOMES HARDER TO GET A CLEAR PICTURE- FROM THE REAR
THE LARGER CANOPY BOW FURTHER REDUCES FORWARD VISIBILITY
DISTORTION WORSE AROUND EDGES-BOTTOM FRONT DIFFICULT TO JUDGE DURING LANDINGS
APPEARS TO HAVE SMALLER FIELD OF VISION FROM RCP&FCP-FCP RAINBOWS WITH REFLECTIONS
CANOPY RAIL IS A LOT THICKER WHICH HAS A NOTICEABLE EFFECT ON THE VISIBILITY
SEAT REFERENCE FOR THE FRONT COCKPIT IS DIFFERENT
CANOPY IS THICKER WHICH LEADS TO REDUCED VISIBILITY
FRONT SEAT: CANOPY RAIL WIDER WHICH MAKES COMPARISON WORSE FOR BACK SEAT
PILOT VISIBILITY(ESPICALLY FOR LANDINGS)
REAR COCKPIT VISIBILITY REDUCED SIGNIFICANTLY
LAST THING THEY NEED TO DO TO THE T-38 IS FURTHER RESTRICT THE VISIBILITY OF BACK SEATER
REDUCES RCP VIS OVERALL VISIBILITY IS TERRIBLE
THE FRONT WINDSHIELD IS OBSTRUCTED BY CANOPY BOW ALSO
MAKES HARDER TO SEE WHEN DOING TORNING REJOINS
NOT A GOOD IDEA
LOW LEVEL MISSION DISTORTION IS POTENTIALLY DANGEROUS
VISIBILITY FROM RCP IS MUCH WORSE
HURTS DEPTH PERCEPTION THINGS APPEAR SMALLER THAN THEY ARE
VERY DISTORTED CROSS BAR IN THE F/C/P IS SO THICK THAT IT TAKES AWAY SOME OF THE
ALREADY LIMITED VIEWING AREA IN THE R/C/P, VERY DISTORTED ON THE SIDES
BASICALLY IT SUCKS
VERY DIFFICULT TO SEE FROM THE R/C/P DUE TO WIDER CANOPY BOW ON FRONT CANOPY
LANDING DIFFICULT TO JUDGE DUE TO LOWER EDGE DISTORTION
DISTORTION IS TERRIBLE. LANDINGS FROM RCP WERE DIFFICULT IF TRYING TO LOOK THROUGH
FRONT WINDSCREEN. OVERALL IT IS VERY POOR VISUAL QUALITY.
THE THICKER GLASS OFFSETS WHAT YOU ARE LOOKING FOR; ESPECIALLY WHEN REJOINING
IN FORMATION. LANDING PICTURE IS DISTORTED ALSO.
VERY POOR FORWARD VISIBILITY CAUSES HIGH FLARES BOTH COCKPITS.
F/C/P PILOT THOUGHT IT WAS LIKE LOOKING THROUGH SOMEONE ELSE'S PERSCRIPTION SUNGLASSES
ON LANDING I FELT CLOSER TO THE GROUND THAN I ACTUALLY WAS. SET GROUND FOR HIGH
FLARES ON FIRST THREE APPROACHES.FELT VERY UNCOMFORTABLY LOW COMING INTO
THE OVERRUN BUT THE BOX MADE NO COMMENTS AND I WAS TOUCHING DOWN UP TO
2000 FT. DOWN.

WIDER CANOPY RIM HIDES OTHER AIRCRAFT
NOTICED SLIGHT PRISM EFFECT NEAR LOWER EDGE OF FRONT CANOPY
BIG BOW MAKES HARD TOO SEE WHILE TAXIING
A SLIGHT DISTORTION EXISTS WHICH COULD PROBABLY BE GOTTEN USED TO IF ALL
WINDSCREENS WERE THE SAME.
IP WAS IN FRONT SEAT/INEXPERIENCED STUDENT IN BACK. WHEN LOOKING DOWN OR AT SHORT
DISTANCES-THE VISION WOULD BE SLIGHTLY DISTORTED-THE DISTORTION WAS CHARACTERISTICALLY
CLOUDY TO HAZY. IT WAS LIKE LOOKING THROUGH UNFOCUS BINOCULARS. WHEN YOU FOCUS
YOUR AIMPOINT TO A DISTANCE OBJECT, THE DISTORTION WENT AWAY.
STUDENT WAS IN RCP FOR INSTRUMENT (HOODED) SORTIE. IN THE FCP, NEAR THE RUNWAY
THE VISION WAS BLURRED SLIGHTLY BY THE CANOPY'S DISTORTION.
DISTORTION IN FRONT "L" OF CENTER WINDSCREEN
OK FOR VISIBILITY, BUT WHEN FLYING TOWARDS SUN IT WAS VERY HAZY TO LOOK THROUGH.
THE DISTORTION WAS A LITTLE WORSE, BUT THE LOWER CANOPY BOW
MAKES FORMATION VISIBILITY BETTER.
LOOKING THRU THE LOWER PORTION OF THE WINDSCREEN THE VISION IS BLURRED
DISTORTION WORST TORWARDS BOTTOM-- MAKES YOU FEEL VERY STEEP
FRONT COCKPIT CANOPY BOW THICKNESS DOES CAUSE SOMEWHAT OF A FORWARD VIS
PROBLEM. IT IS ALMOST DIRECTLY EYE LEVEL.
DON'T LIKE IT
CANOPY BOW SEEMS LOWER IN FRONT CAN'T SEE FROM BACK
FCP CANOPY BOW SEEMS TO BLOCK VIEW MORE THAN NORMAL
SP WAS ON 1ST SORTIE SO HAD LITTLE TO COMPARE
IP GRADED FRONT C/P BASED ON F/C/P EXPERIENCE IN PAST
R/C/P IS WORSE DO TO MORE RESTRICTED VISIBILITY FROM WIDER CANOPY BOW.
FROM DISTANCE WITH HAZE HARD TO SEE RUNWAYS
CANOPY BOW TOO LOW. FROM BACK SEAT CAN'T SEE OUT AT ALL.
TOO BIG A CANOPY BOW
THE VISIBILITY IS RESTRICTED FROM THE BACK COCKPIT DUE TO A WIDER CANOPY BOW.
RCP NO FLAP SPORTY CANOPY BOW TOO LARGE
LOTS OF COLOR DISTORTION (PRISM EFFECT) NEAR FRONT OF WINDSCREEN
AND BOTTOM BACK CORNERS
COLOR AND LINEAR DISTORTION
DISTORTION APPEARS TO BE RIGHT AROUND THE EDGE OF THE FRONT WINDSCREEN
IF YOU FLEW WITH THIS WINDSCREEN ALL THE TIME YOU COULD PROBABLY ADJUST
FCP DISTORTION
WHEN DOING NO FLAP STRAIGHT IN LANDINGS THE REAR COCKPIT MEMBER IS FORCED TO
LOOK THROUGH THE BOTTOM PORTION OF THE FRONT COCKPIT WINDSCREEN
THAT VIEW IS BLURRED AND QUITE DISTORTED. DURING NORMAL PATTERN LANDINGS
THE PITCH PICTURE IS LOWER AND DISTORTION IS LESSENED.
TOO THICK BOW
DEFINITE DISTORTION DURING TAKE-OFFS AND LANDINGS
VERY BAD ON LANDING AND TAKE OFF

VANCE TAIL# 3721

		T-38 DEBRIEFING SUMMARY TAIL# 3721			
VANCE AFB					
	DATE	AUG SEPT OCT NOV DEC			
		JAN FEB MAR APR MAY			
TOTAL FLIGHT TIME HRS:		215.13338			
		COMPARISON			
		MULTIPLE			
	DISTORTION	IMAGES	REFLECTIONS	HAZE	OVERALL
MUCH BETTER	7	4	6	11	6
BETTER	11	19	21	23	23
SAME	110	153	127	133	104
WORSE	47	5	27	12	45
MUCH WORSE	10	3	4	3	5
TOTAL NUMBER OF REPORTS		183			

YANCE TAIL # 3721

COMMENTS
EXACTLY WHERE THE PILOT TUBE ATTACHES TO THE A/C-REAR C/P-NO PROBLEMS LANDING BUT
ATTACH BOLTS FRONT W/S AND IP'S W/S WERE MORE NOTICEABLE-PICTURE AREA LANDING
FRONT COCKPIT-VIEW THROUGH FRONT WINDSCREEN IS DEFINITELY DECREASED DUE TO THE
MOUNTING BRACKET-NOT A MAJOR PROBLEM ON A CONTACT SORTIE-COULD BE MORE OF A PROBLEM
IN FORMATION(TRAIL-REJOIN-ETC)-REAR COCKPIT-THE NEW MOUNTING FOR THE FRONT W/S
RESTRICTS THE FORWARD VIEW INTERFERING WITH LANDING VISIBILITY SOMEWHAT
NO PROBLEMS!!!!
NO PROBLEM FROM EITHER COCKPIT
NO PROBLEMS-- NO CHANGES
FRONT COCKPIT NOTICED SLIGHT POLARIZATION RAINBOWS-PROBABLY DUE TO COMBINATION
OF DARK HELMET VISOR AND WINDSCREEN
NO PROBLEMS NOTED
ACTUAL VISIBILITY IS REDUCED DUE TO EXTRA LARGE CANOPY BOW
SOME DISTORTION NEAR BASE-BUT NOT CRITICAL AT ALL-INCREASED THICKNESS OF THE CANOPY
ATTACH PT MAY HAMPER VISIBILITY FROM THE REAR COCKPIT--MY COMPASS APPEARS TO
BE LOWER IN THE PILOTS FIELD OF VISION
FCP- DISTORTION ALONG BASE OF SCREEN IS WORSE-RAINBOW REFLECTION DURING IMC OPS
TECHNIQUES FOR ADJUSTING SEAT HEIGHT FROM FRONT CAN NO LONGER BE USED
CANOPY HAS NO SCRATCHES WHICH WAS A SIGNIFICANT FACTOR
LARGER CANOPY BOW HINDERS FORWARD VISIBILITY FROM INSTRUCTORS VIEW-ENLARGED
CANOPY BOW & THE POSITION OF MAG COMPASS MAKES VISIBILITY A LOT MORE DIFFICULT
THERE IS ALSO A LITTLE MORE DISTORTION LOOKING FORWARD
THERE WAS A NOTICEABLE AMOUNT OF DISTORTION WHILE FLYING IN THE F/C/P-IN R/C/P THERE
WAS NO SIGNIFICANT DIFFERENCE IN DISTORTION-ON FIRST SORTIE CPT SMITH FLEW SOLO
AND THE SECOND DUAL BUT STILL IN THE F/C/P- HIS INFO ON THE R/C/P IS FROM DISCUSSION
WITH LT CHAEL WHO RODE IN THE R/C/P ON THE SECOND SORTIE
REDUCES VISIBILITY DUE TO LARGE CANOPY BOW-YOU NEED TO PAINT HARDWARE
ON NEW PLATING TO AYOID GLARE
GET SOME RAINBOW COLOR EFFECT AT AN ANGLE WHEN LOOKING THROUGH THE FRONT
CANOPY FROM THE REAR COCKPIT
FROM FRONT COCKPIT- SLIGHT DISTOERTION IN MIDDLE OF WINDSCREEN AT THE BOTTOM
IN THE YERY FRONT-NO FACTOR TO VISIBILITY-NO DIFFERENCE IN BACK COCKPIT NOTED
THE EXTRA CANOPY BOW RESTRICTS VISIBILITY OUT THE FRONT-SILVER NUTS DISTRACTING
LARGER CANOPY BOW REDUCES VISIBILITY(ESP FORMATION SORTIES)- DOUBLE IMAGE
WHEN VIEWING THROUGH LOWER RIGHT PORTION OF FRONT CANOPY
LARGER CANOPY BOW- SMALL TINT TO CANOPY-HARD TO SEE ICE ON WINDSCREEN
NOT MUCH DIFFERENCE
NO NOTICEABLE DIFFERENCE F/CP OR R/C/P ON DAY FORMATION WITH CLEAR WEATHER
SOME DISTORTION SEEMED MORE LIKE REFLECTIONS-SEEMED DARKER-SOME DISTRACTION
BECAUSE OF THE 2 BARS HOLDING THE WINDSCREEN BETWEEN COCKPITS-BUT NO FACTOR
THE ADVANTAGES PROBABLY OUTWEIGHT DISADVANTAGES- SLIGHT DISTORTION WHEN
CLIMBING AND CLEARING FOR TRAFFIC ON THE HORIZON
NO NOTICEABLE DIFFERENCE EXCEPT THE SHEET METAL OVER THE FRONT EDGE OF THE NEW SCREEN
EXTENDS HIGHER THAN OLD-WITH THE FRONT SEAT ALL THE WAY UP, I COULD NOT SEE THE BASE
OF THE PILOT TUBE-WITH STANDARD SCREEN I CAN SEE THE BASE OF PILOT TUBE,PLUS A PORTION
OF NOSE COWLING-COULD CAUSE STUDENT DIFFICULTY DETERMINING NORMAL SEATING HEIGHT
CLEARER VISIBILITY DUE TO NO SCRATCHES!!!!!
CANOPY BOW IN FRONT COCKPIT IS TOO WIDE-RESTRICTS SOME VISIBILITY FROM FRONT
CANOPY BOW IS TOO LOW-IT RESTRICTS VISION DURING ALL PHASES OF FORMATION WHERE
LEAD IS IN THE FORWARD PORTION OF WINDSCREEN
THE WINDSHIELD MAGNIFIES OBJECTS WHILE SITTING ERECT AND DISCONTINUES MAGNIFICATION

WHEN YOU DUCK YOUR HEAD- SLIGHT GREEN PATCHES ON THE RIGHT AND LEFT FORWARD EDGES
WHERE CANOPY ATTACHES TO AIRFRAME
CANOPY BOW RESTRICTS FORWARD VISION
WITH THE AMOUNT OF TIME SPENT IN THE WEATHER IT WAS DIFFICULT TO JUDGE
THE DIFFERENCE BETWEEN THE TWO
CANOPY BOW WAS MUCH BIGGER WHICH REDUCED VISION FROM THE REAR
VERY BAD REFLECTION FROM BOTH STUDENTS HELMET AND MY FLIGHT SUIT IN BACK
YOU CAN SEE THE SLIGHT OILY RAINBOW COMPOSITION AND IT IS SLIGHTLY DARKER-PREVENTS GLARE
AND REFLECTION BUT IS HAZIER-CANOPY BOW SHAPE THICKER-CUTS DOWN VISIBLITY SLIGHTLY
NO SIGNIFICANT IMPACT OVERALL
FIELD OF VIEW REDUCED
IN FRONT SEAT SEVERELY DISTORTS DURING LANDING PHASE-THERE WAS ALSO A RAINBOW
EFFECT BEHIND US- BACK SEATER REPORTED PROBLEM WITH LARGER CANOPY BOW IN LANDING
AND TAKEOFF
NO DIFFERENCE
YELLOW TINT
THE STUDENT IN FCP(LT HOWE)DID NOT NOTICE ANY DIFFERENCE BETWEEN NEW/OLD WINDSCREEN
HOWEVER-AFTER ONLY 5 RIDES,I(LT CHAEL)FEEL HE HAS LITTLE ON WHICH TO BASE COMPARISION
ON C5105 22SEP HE WAS JUST BEGINNING TO SEE THE PICTURES ON LANDINGS-TODAY C5106 HE
FAILED TO SEE THE PROPER ROUNDOUT POINT AND WAS EXTREMELY INCONSISTENT-HI/LOW ETC.
FRANKLY I FEEL THIS WINDSCREEN HAS A SERIOUS NEGATIVE IMPACT ON HIS TRAINING-
DUE TO THE DISTORTED DIFFERENT PICTURE PROJECTED BY THE SCREEN
I HAVE FLOWN THIS A/C FROM FRONT & REAR SEATS- THIS SORTIE IN REAR NOTED NO DIFFERENCE
LARGER CANOPY BOW REDUCES FIELD OF VIEW IN BOTH COCKPITS
I NOTED SOME POLARIZATION(MULTIPLE COLORS)AT THE LOWER EDGE OF WINDSCREEN-LEFT
FORWARD PORTION- OCCURED WITH THE SUN AT OUR BACK-SHINING OVER MY SHOULDER/HELMET
ALSO THE CANOPY BOW APPEARS A BIT LARGER-BUT DIDN'T AFFECT INFLIGHT VISIBILITY
DUE TO LARGER CANOPY BOW HARDER TO SEE
FROM THE BACK SEAT THE FRONT CANOPY BOW IS THICKER- IT WAS HARDER TO SEE THE RUNWAY
AND CHECK RUNWAY ALIGNMENT FROM THE BACK SEAT
PLEXY GLASS ITSELF SEEMS TO BE BETTER-LIKE TINT BUT DISLIKE ENLARGED CANOPY BOW
STUDENT THOUGHT THAT YELLOW TINT ELIMINATED SOME REFLECTIONS-BUT MIGHT MAKE IT
HARDER TO SEE IN HAZE- IP: NO REAL DIFFERENCE OTHER THAN LARGER CANOPY BOW
NO DIFFERENCE NOTED
NO EFFECT ON TRAINING
ONLY DIFFERENCE NOTED WAS WHEN I ADJUSTED MY SEAT-USUALLY LOWER SEAT APPROX. 1 INCH
THIS JET DIDN'T HAVE TO LOWER THE SEAT AT ALL TO SEE REFERENCES USED TO ADJUST SEAT
WINDSHIELD ITSELF GOOD--CANOPY BOWS ARE TOO LARGE
A LOT OF GLARE
VERY CLEAN W/S-COULD SEE VERY WELL-BETTER THAN A NORMAL CANOPY-CANOPY BOW
THICKER BUT I DON'T FEEL IT'S TOO THICK-IMPROVEMENT OVER NORMAL W/S
THE DISTORTION IN THE FRONT C/P IS EXCESSIVE
REFLECTIONS:WHEN LOOKING INTO THE SUN(CLEAR DAY)CANOPY WOULD SHOW RAINBOW EFFECT
ON A MAJORITY OF THE CANOPY AS SEEN FROM THE REAR COCKPIT ONLY- FRONT COCKPIT
SAW THIS ONLY ON THE EDGES (NO FACTOR)
VISIBILITY FROM BACK SEAT SLIGHTLY IMPROVED DURING LANDING PHASE
THICKNESS OF BOW CUT FORWARD VISIBILITY DOWN-MAKES REAR SEAT LANDINGS MORE SPORTY
DISTORTION-REFLECTIONS-ETC SEEM TO BE SAME AS THE OLD W/S-BACK SEAT VISIBILITY
ON FINAL SEEMS TO BE SLIGHTLY IMPROVED
SUPER CANOPY.
RESTRICTION TO VISIBILITY IS GREATER AT 1 AND 11 O'CLOCK POSITIONS--APPEARS TO BE
SMALLER VISUAL PICTURE LOOKING FORWARD

STUDENT CONSISTENTLY FLARED HIGH--DIDN'T HAVE THIS PROBLEM BEFORE
DIFFICULT TO CHECK RUNWAY ALIGNMENT ON FINAL APPROACH--DIFFICULT TO JUDGE GLIDE
PATH BECAUSE OF THE THICKNESS OF THE CANOPY BOW
NO CHANGE NOTED
BOTH IP'S(FCP/RCP)SAW NO DIFFERENCE OTHER THAN LARGER CANOPY BOW
BACKSEAT VISION MAY BE SLIGHTLY IMPROVED-OTHERWISE IT SEEMS THE SAME
FLARED HIGH.
STUDENT IN FRONT COCKPIT COMMENTED ON DISTORTION IN THE FRONT LOWER WINDSHIELD
(LOOKING BY THE PILOT BOOM) DURING LANDING
STUDENT NOTED DISTORTION IN LANDING PHASE
DID TWO LANDINGS-FIRST ONE FLARED HIGH-SECOND ONE WAS BETTER--THINK IT IS JUST
A QUESTION OF GETTING USED TO IT
SLIGHT DISTORTION OF VERTICAL AND HORIZONTAL STRAIGHT LINES
CONTRIBUTED TO HIGH FLARES-DISTORTION MAKES FLYING FORMATION DIFFICULT
STUDENT IN FRONT SEAT FLARED HIGH TWICE
CLEAR DAY CAN'T REALLY COMPARE REFLECTIONS-HAZE SEEMS TO BE SLIGHTLY YELLOWER TINT
LOOKING THRU THE CANOPY-DISTORTION STRAIGHT OUT FRONT OK BUT AROUND THE
1 AND 11 O'CLOCK POSITION ON -A SLIGHT DISTORTION NOTED
MISSION FINDEN DUAL CONTACT VARIABLE AIRSPEEDS AND ALTITUDES-NO DIFFERENCE WAS
NOTED BETWEEN THIS WINDSHIELD OR ANY OTHER WINDSHIELD I HAVE EXPERIENCED
EXPOSED HARDWARE IS DISTRTACTING
ONLY REAL DIFFERENCE IS THE YELLOW TINT ON THE SCREEN AND
THE OVER SIZED CANOPY BOW
FROM F/C/P, THERE IS A BIG PROBLEM WITH MULTIPLE IMAGES AND DISTORATION LOOKING
OUT THE FRONT WINDSCREEN. ALSO THERE ARE COLOR RINGS THAT ARE VISIBLE IN THE FRONT
WINDSCREEN THAT MAKE VISION STRANGE. THE EXTRA THICK CANOPY BOW CUTS DOWN
ON A LOT OF VISIBILITY
WINDSHIELD SEEMED VERY COMPARABLE TO OLD TYPE WINDSHIELD IN ALMOST ALL RESPECTS
CONTRIBUTES TO HIGH FLARES / SINKING FLARES FROM STUDENT PILOT
IMAGE DISTORTION MUCH WORSE CLOSE TO CANOPY RAIL AND CANOPY BOW COMPARED
TO NORMAL WINDSCREEN. HOWEVER VISIBILITY STILL GOOD AND WAS NO FACTOR DURING THE
MISSION. VISIBILITY WISE THIS WINDSCREEN WOULD BE SUITABLE FOR REGULAR USE
IN THE UPT MISSION.
THIS WINDSCREEN GIVES VERY BAD DISTORTION DURING LAND PHASE----
DUE TO CURVATURE OF LOWER PART. I CONSIDER IT DANGEROUS TO FLY
I DIDN'T NOTICE ANY DIFFERENCES BUT IT WAS CLEARER
NO RECOGNIZABLE DIFFERENCE, OVERALL
REFLECTION WORSE THAN OTHER WINDSCREENS WHEN LOOKING AT SUN
DID NOT NOTICE ANY DIFFERENCE AT ALL BETWEEN THIS CANOPY AND THE OTHERS.
SINCE THE VISUAL EFFECT IS THE SAME AND THE CANOPY IS MUCH SAFER,
THE USE OF THIS NEW MATERIAL IS A VERY GOOD IDEA
THE THICK CANOPY BOW DOES NOT AFFECT THE FRONT SEAT BUT MAKES IT A BIT MORE DIFFICULT
TO LAND FROM THE BACK SEAT.
CANOPY BOW THICKER NO RESTRICTION TO VISIBILITY COMPARED TO OLD WINDSCREEN
FROM FRONT COCKPIT
REFRACTION IS DIFFERENT; HOWEVER NOTHING THAT A SHORT PERIOD OF EXPOSURE AND
EXPERIENCE WOULD NOT OVERCOME.
LESS FORWARD VISIBILITY
I HAD A TALL STUDENT WHO COMPLAINED THAT THE ROW OF RIVETS ATTACHING THE
WINDSCREEN INTERFERED WITH HIS VIEW
CANOPY BOW FRONT AND REAR TOO THICK. PLEXIGLASS ITSELFS SEEMS ABOUT THE SAME.
I DIDN'T REALLY NOTICE ANY DIFFERENCE.

THICKER WINSCREEN MOUNTS REDUCE YISIBILITY SLIGHTLY.
BRIGHTLY FINISHED MOUNTING BOLTS ARE A SLIGHT DISTRACTION
IT SEEMED TO GIVE MORE RUNWAY DISTORTION AT HIGH PITCH PICTURES.
DIDN'T NOTICE ANY DIFFERENCE.
DISTORTS AT LOW ALTITUDE.
COULDN'T TELL ANY DIFFERENCE.
FLIGHT WAS OF SHORT DURATION-- NO NOTICEABLE DIFFERENCES IN THE WINDSCREEN.
FORWARD YISION IS DISTORTED APPROX 1-2 OVERRUNS OUT ON FINAL.
TURNING BLUE TOWARD THE LEADING EDGE.
NOTICEABLE BUT SLIGHT DISTORTION LOOKING STRAIGHT AHEAD AND DOWN.
RAINBOW EFFECT AROUND EDGES.
NO DIFFERENCES NOTED.
ONLY DIFFERENCE IS THE WIDTH OF THE CANOPY BOW.
SLIGHT DISTORTION FROM R/C/P
DIDN'T DETECT ANY NOTICEABLE DIFFERENCES.
DID NOT MAKE ANY LANDINGS REDUCED YISION
YERY CLEAR REDUCED GLARE
FRONT CANOPY BOW IS TOO LARGE-- RESTRICTS FORWARD YISIBILITY MUCH WORSE
THAN ALREADY IS.
COULD NOT TELL ANY DIFFERENCE
REDUCED YISIBILITY DUE TO LARGER CANOPY BOW.
LARGER CANOPY BOW CAUSED LARGER BLIND SPOT
BACK SEAT YISIBILITY WAS SLIGHTLY OBSTRUCTED.
I KEPT SEEING A RAINBOW ON THE SIDES OF THE FORWARD CANOPY.
WORST PART IS THE LARGER CANOPY BOW WHICH REDUCES YISIBILITY
STUDENT LOSES SIGHT OF LEAD YERY EASY DURING PITCHOUT AND REJOINS.
CUTS DOWN ON ALREADY LIMITED YISION FROM THE BACK SEAT
STUDENT SEEMED TO FLARE A LITTLE HIGHER THAN NORMAL
FORMATION FLIGHT. FROM BACK SEAT LOOKING OUT THE SIDE OF FRONT CANOPY THE DISTORTION
WAS MUCH WORSE THAN THE NORMAL CANOPY. ALMOST A RIPPLE EFFECT DISTORTION.
ON PITCHOUTS WE LOST SIGHT OF THE LEAD TWICE BECAUSE OF THE CANOPY TINT.
IT TENDS TO BLEND THE HORIZON INTO ONE BIG COLOR BLOB HIDING DISTINCT FEATURES
AT THE FURTHER DISTANCES. COULD SEE LEAD EASIER OUT REAR COCKPIT CANOPY
EASIER FOR THE SAME DISTANCE
THE CANOPY IS MUCH WORSE FOR DISTORTION AND MULTIPLE IMAGES, ESPECIALLY
WHEN YOU LOOK OUT THE SIDES OF THE CANOPY. THE THICKER CANOPY BOW CUTS DOWN
ON THE FRONT SEAT YISIBILITY.
LOOKING FROM THE FRONT COCKPIT DIRECTLY OVER THE NOSE THE WINDSCREEN HAD A PRISM
EFFECT CAUSING RAINBOW LIKE IMAGES. THIS DISTORTION MADE LEAD DIFFICULT TO
SEE DURING STRAIGHT AHEAD REJOINS.

		T-38 DEBRIEFING SUMMARY TAIL# 8402			
RANDOLPH AFB					
	DATE	SEPT OCT NOV DEC JAN FEB			
		MAR MAY JUN JUL AUG SEPT			
TOTAL FLIGHT TIME HRS:		125.11667			
		COMPARISON			
		MULTIPLE			
	DISTORTION	IMAGES	REFLECTIONS	HAZE	OVERALL
MUCH BETTER	5	7	6	2	5
BETTER	8	11	14	12	16
SAME	42	72	48	60	34
WORSE	47	17	34	29	48
MUCH WORSE	10	5	9	6	10
TOTAL NUMBER OF REPORTS		111.4			

COMMENTS
CHANGES SOME REFERENCES FOR PILOT - SEAT ADJUSTMENT IN FCP.
SHOWS MULTIPLE IMAGES FROM REAR COCKPIT WHEN CHANGE PITCH
THERE IS SLIGHT DISCOLORATION THROUGH THE WINDSCREEN AND THE CANOPY BOW IS TOO BIG
LARGE CANOPY BOW WILL AFFECT CLEARING
DISTORTED VIEW IN THE 12 O'CLOCK PORTION OF THE WINDSCREEN (FRONT OF W/S ONLY)
LARGER CANOPY BOW RESTRICTS VISIBILITY FROM REAR COCKPIT
DARKER TINTING MADE FORWARD VISION WORSE.
SCRATCHED???
IRISATION (SPECTRUM) IN FRONT SHIELD
MORE GLARE AND REFLECT ON LOOKING INTO THE SUN
COLOR PATTERNS ARE VISIBLE NEAR THE FRINGES, ESPECIALLY NEAR THE NOSE
REAR COCKPIT VISIBILITY WORSE DUE TO THICKER CANOPY BOW
BAD!!!!!
LARGE CANOPY BOW HARD TO SEE AROUND
VERY POOR VISIBILITY IN LIGHT TO MODERATE RAIN SHOWER
LITTLE BIT OF DISTORTION IN LOWER WINDSCREEN
FROM FRONT COCKPIT PILOT SAW RAINBOW TYPE REFLECTION
CANOPY BOW TOO THICK
COLOR AND DISTORTION ALONG CANOPY EDGES
GIVES COLORED HUES IN THE SUN
THERE IS A VISIBLE SPECTRUM EVIDENT AROUND FRONT EDGES OF WINDSCREEN
DISCONNECTING WHEN FLYING INTO SUN.
SOME RAINBOW EFFECT, DISTORTION AROUND EDGES OF FRAME, NOT TOO BAD THOUGH
A LOT OF DISTORTION RUNNING HORIZONALLY ACROSS THE WINDSCREEN
RAINBOW IMAGE WAS A DISTRACTION AS WELL
DISTORTION WHERE WINDSHIELD CONNECTS TO AIRCRAFT
CANOPY BOW APPEARS TO BE LARGER
DURING THE TWILIGHT HOURS THE CANOPY MADE IT EVEN DARKER MAKING DEPTH
PERCEPTION WORSE
NO REAL PROBLEMS WITH IT
MAKES OTHER AIRCRAFT LOOK CLOSER
MAKES RUNWAY LOOK CLOSER IN LANDING FLARE
DEFINITE WAVINESS LOOKING THRU BOTH NEW SCREENS SHORT FINAL
SOME POLARIZATION OF LIGHT ON WINDSCREEN WHEN FLYING THROUGH SCUD
FRAME TOO LARGE
THE CANOPY HAS ABOUT A 2" BAND OF DISTORTION AROUND THE FRONT COCKPIT
CANOPY BOW WHICH MAKES IT HARDER TO CLEAR AND SEE DURING LANDINGS
TOO MUCH DISTORTION AND COLOR CHANGES WHEN COMPAIRING TO A NORMAL CANOPY.
ALSO WIDER CANOPY BOW REDUCES VISIBILITY
LESS VISIBILITY DUE TO MORE FRAME CONSTRUCTION
BIGGER FRAME HAS A NEGATIVE EFFECT ON CLEARING
FORWARD VISIBILITY TERRIBLE RAINBOW EFFECT FROM SUN
CANOPY BOW OBSCURES VISSION A LITTLE MORE
DEPTH PERCEPTION IN FLARE BAD
BIG CANOPY BOW REDUCES FORWARD VIS FROM BACK SEAT
R/C/P PILOTS VIEWPOINT
F/C/P MINIMAL EFFECT
RESTRICTED AREA OF GLASS DUE TO CANOPY BOW THICKNESS PLUS DISTORTION
ARE BIGGEST DRAWBACKS
NEITHER PILOT COULD TELL A DISTINCT DIFFERENCE IN THE WINDSHIELD ON THIS SORTIE
RCP VISIBILITY IS NOT DEGRADED FOR DAYTIME OPERATION

LARGE BOW REDUCES VIS FROM BACK
WORSE
NO GOOD
PRISM RAINBOW EFFECT FCP IN BRIGHT SUN
RCP DISTORTION TO THE RIGHT OF FCP GLARE SHIELD
DISTORTION EXTREMELY BAD RCP & FCP CANOPY BOW TOO BIG
VERY DISTORTED PICTURE LOW ON THE WINDSCREEN
GET RID OF IT MARGINALLY SAFE
RAINBOW IMAGES WHEN WET DISTORTS THE RUNWAY
CAUSES EYE STRAIN DEFINITE DIFFERENCE BETWEEN CANOPY GLASS BETWEEN FRONT
WINDSCREEN AND ACTUAL CANOPY
WINDSHIELD IS NOT THE PROBLEM, THE PROBLEM IS THE THICK CANOPY BOW
WIDE CANOPY BOW
RAINBOW EFFECT AROUND EDGES OTHERWISE NO PROBLEMS
CANOPY BOW TOO BIG MAG COMPASS AT EYE LEVEL

REESE TAIL #3681

		T-38 DEBRIEFING SUMMARY TAIL# 3681			
REESE AFB					
	DATE	DEC JAN FEB MAR APR MAY			
		JUN JUL			
TOTAL FLIGHT TIME HRS:		263.93333			
		COMPARISON			
		MULTIPLE			
	DISTORTION	IMAGES	REFLECTIONS	HAZE	OVERALL
MUCH BETTER	25	30	28	34	31
BETTER	63	45	53	59	72
SAME	104	141	130	119	97
WORSE	33	6	15	12	23
MUCH WORSE	1	1	0	1	2
TOTAL NUMBER OF REPORTS		225			

REESE TAIL #3681

COMMENTS
SLIGHTLY HARDER TO CLEAR WITH THE LARGER CANOPY RAIL-BUT TAT IS AN AMPLE TRADE-OFF
KNOWING I WON'T BE PULYERIZED BY BIRDS--IF YOU CAN TRY TO IT MAKE SMALLER
ONLY STUDENTS SECOND FLIGHT T-38 FLIGHT --NO DIFFERENCE
ADDED WIDTH OF FRONT CANOPY BOW IMPAIRS FORWARD YISION
COULDN'T TELL THE DIFFERENCE
DOESN'T GLARE AS MUCH-CANOPY BOW IS BIGGER & THERFORE RESTRICTS THE RCP FORWARD VIEW
DISTORTION SEEMED TO BE ALONG THE LOWER EDGE OF CANOPY AND
SEEMED LIKE THE CANOPY WAS TINTED
APPEARED NORMAL TO ME. NO DIFFERENT
SEEMED TO BE DARKER ---KIND OF LIKE SMOKED GLASS
FORWARD YISION IS ONLY SLIGHTLY RESTRICTED DUE TO THE SLIGHTLY THICKER BOW
AND SLIGHTLY HIGHER OUTSIDE GLARE SHIELD
CANOPY BOW TO BIG
IP CANNOT SEE AS WELL TO LAND AND WE NEED ALL THE ADVANTAGE WE CAN GET
NICE
YISIBILITY FROM REAR COCKPIT YERY GOOD
DISTORTION ON BOTTOM 4 TO 5 INCHES--OBSERVED DOING OYER-THE-TOPS
MULTIPLE WATER SPOTS AND DISTORTION IN THE UPPER MIDDLE PORTION
OF THE WINDSCREEN AFFECTED FORWARD YISIBILITY ADYERSERLY
SIDES AND LOWER MIDDLE PORTION OF WINDSCREEN CLEAR
CANOPY BOW IS SLIGHTLY THICKER. THE MODIFICATION REDUCES THE AMOUNT OF
FORWARD YISIBILITY DUE TO ITS THICKNESS.
CANOPY BOX IS THICKER REDUCING YISIBILITY.
NOTICE A YERY SLIGHT DISTORTION--DID NOT DETRACT FROM THE SCREENS OYERALL PERFORMANCE.
I LIKE IT
WINDSCREEN CAUSED A DISPLACED IMAGE RELATIYE TO SIDE CANOPY
ILLUSION NOTED ONLY FROM BACKSEAT.
LARGER CANOPY BOW REDUCES FORWARD YISIBILITY FROM R/C/P
ENLARGED CANOPY RAILS BLOCKS YISIBILITY-CLEAN CANOPY HELPS THE YISIBILITY
DISTORTIONS MADE LANDING PHASE A LITTLE MORE DIFFICULT--OTHERWISE OK
LARGER CANOPY BOW REDUCES FORWARD YISIBILITY FROM RCP
BEEFED UP CANOPY RAIL CUTS DOWN YIS SLIGHTLY
FRONT SEAT PILOTS LIKE THE EXTRA PROTECTION AFFORDED FROM BIRDSTRIKES
I DON'T LIKE WHERE THEY PUT THE MAG COMPASS
NO DIFFERENCE NOTED
HUGE FRAME IMPARES FORWARD YISION MUCH MORE DIFFICULT TO JUDGE RUNWAY FROM
BACK SEAT DUE TO EXTREME OPTICAL DIFFERENCES BETWEEN CANOPY AND WINDSCREEN
HAZE CAUSES A DISTORTED YIEW LARGER CANOPY BOW ALSO HURTS YISION
WIDTH OF F/C/P CANOPY BOW DECREASES R/C/P YISIBILITY
RAINBOW TYPE IMAGES NOTED FROM FRONT CANOPY
NO PROBLEMS!
NO NEED TO FILL OUT PAPERWORK ANYMORE!
DUE TO SENSE OF SECURITY. DEATH TO THE BIRD POPULACE
CLEAN CANOPY HELPS YIS MORE THAN ANYTHING
WINDSHIELD PRODUCES NO YISUAL ILLUSIONS, THIS IS PARTLY DUE TO THE FACT IT IS CLEAN
HOWEYER THICKER RAIL RESTRICTED YISIBILITY
BOW TENDS TO BLOCK OUT AND INTERFERE WITH CLEARING
SEYERELY LIMITED YISIBILITY FOR REAR COCKPIT FROM THE WIDE BAND
ALSO THERE WAS AN INCREASED AMOUNT OF REFLECTIONS
WHISKEY COMPASS IS TOO LOW
EXCELLENT WINDSCREEN

REESE TAIL #3681

MINOR DRAWBACK
CANOPY BOW OBSCURES FORWARD VISIBILITY FROM R/C/P DUE TO LARGER CANOPY BOW
CANOPY BOW OBSCURES TOO MUCH VISION FROM REAR SEAT
NO NEED TO CONTINUE WRITEUPS EXPERIMENT SHOULD BE OVER
POOR VISIBILITY DURING APPROACHES AND LANDING FROM RCP LOOKING FORWARD
IN OTHER WORDS NOT AS MUCH WINDOW TO LOOK THRU DUE TO THICKER BOW
BETTER

SHEPPARD TAIL # 3750

		T-38 DEBRIEFING SUMMARY TAIL# 3750			
SHEPPARD AFB					
	DATE	NOV DEC JAN FEB MAR			
		APR MAY JUN JUL AUG SEPT			
TOTAL FLIGHT TIME HRS:		225.05			
		COMPARISON			
		MULTIPLE			
	DISTORTION	IMAGES	REFLECTIONS	HAZE	OVERALL
MUCH BETTER	12	11	16	9	14
BETTER	39	42	51	36	55
SAME	102	122	95	116	85
WORSE	26	8	23	13	28
MUCH WORSE	6	1	2	4	5
TOTAL NUMBER OF REPORTS		184.2			

COMMENTS
THICKNESS OF FRONT CANOPY BOW AND REFRACTION LOOKING INTO THE SUN
CANOPY BOW IS TOO WIDE
THE CANOPY FRAME IS WIDE AND IT REDUCES VISION AT 11 O'CLOCK AND 1 O'CLOCK
THE MATERIAL IS GOOD BUT THE NEW CANOPY BOW IS TOO THICK AND RESTRICTS REAR SEAT
OCCUPANTS VISIBILITY TOO MUCH
CANOPY BOW IS THICKER,TAKES AWHILE TO GET USE TO BUT NO SIGNIFICANT VISUAL DETRACTION
PRISM REFLECTION ON SIDES
THE WINDSCREEN WAS DARKER CAUSING MORE REFLECTIONS
NOT AS CLEAR AS THE NORMAL WINDSCREEN
NO VISUAL ILLUSIONS NOTED,SOME GLARE WAS NOTED, CANOPY BOW IS SLIGHTLY LARGER
NO DIFFERENCE NOTED
NOT MUCH DIFFERENCE FROM THE OLD ONE NOTICED- A LITTLE CLEARER THOUGH AND
NOT AS MUCH DISTORTION - DON'T LIKE THE BIGGER CANOPY BOW
WINDSHIELD SEEMS BETTER, HOWEVER THE WIDER CANOPY BOW RESTRICTS FORWARD
VISION COMPARED TO OLD CANOPY
WINDSHIELD DOES NOT DEICE VERY WELL ON FIRST FLIGHT
NEEDS CLEANING
AGAINST THE SUN
EXCELLENT CANOPY
RAIL IS FINE BUT BOW IS VERY THICK
LIMITS THE IMPROVED VISIBILITY THE CANOPY PROVIDES
NO PROBLEMS
SLIGHT DISTORTION WORST FROM BACK SEAT
DISTORTION IN LANDING FLARE SIMILAR TO T-37 CANOPY WAVINESS NOT EXPERIENCED
IN ANY UN MODIFIED T-38 WINDSCREEN, JUST ABOVE AOA INDICATOR.
LARGER SIZE OF CANOPY BOW REDUCES FORWARD VISIBILITY
VISIBILITY REDUCED DUE TO A THICKER CANOPY RAIL
BETTER VIEW BECAUSE ITS A NEW WINDSCREEN
DISCOLORED AND TINTED APPEARANCE RAINBOW EFFECT
DO NOT LIKE WIDER CANOPY BOW
SMALL VISIBILITY REDUCTION FOR THE BACKSEATER
VERY HARD TO KEEP OTHER AIRCRAFT IN SIGHT FROM RCP WHEN THEY MOVE TO FRONT
OF A/C DUE TO REFLECTIONS IN STRONG SUNLIGHT-- BUT I'LL TAKE THE PROTECTION
DIFFICULT TO SEE RUNWAY WHEN LANDING FROM BACK SEAT. I DON'T LIKE IT.
CANOPY BOW SEEMS THICKER ===LESS FIELD OF VIEW 10 TO 2
HAS A GLARE LIKE A RAINBOW AFFECT YOU LOOKING FROM CANOPY THEN OUT FRONT
IN DARKER OR HAZY SKIES VISIBILITY IS HURT BY WINDSCREEN
THERE WAS SMUDGE MARKS ALL OVER IT BECAUSE THE CREW CHIEF COULDN'T
CLEAN IT LIKE THE OTHERS
VISIBILITY IS GREATLY REDUCED DUE TO LARGE CANOPY BOW
VIS FROM BACK SEAT ON FINAL IS POOR DUE TO CANOPY BOW
BIGGER CANOPY BOW DISTRACTING BOTH COCKPITS
ON THE RIGHT SIDE OF THE WINDSHIELD ABOUT THE CENTER ON A REJOIN THE OTHER
AIRCRAFT BECAME VERY FUZZY. ON LANDING THE DISTORTION LOOKING OVER THE FRONT
AND USING NORMAL LANDING PICTURE CAUSED A HIGH FLARE
IN THE FRONT SEAT DECREASES THE CLEARING CAPABILITY OF THE PILOT
IT SHOWS "POLAROID" COLORS IN SUN
NO CHANGE WITH NEW PAINT
WHAT'S THE DIFFERENCE?
SLIGHTLY REDUCED FORWARD VISIBILITY DUE TO THICKNESS OF CANOPY BOW
FORWARD VISIBILITY LIMITED DUE TO LARGER CANOPY BOW

SHEPPARD TAIL # 3750

IT OBSTRUCTS SOME VISIBILITY FROM RCP
SLIGHT RESTRICTION TO FORWARD VISIBILITY FROM RCP
NO DIFFERENCE
STRONG DISTORTION FRONT CORNER ABOVE HELMET OF FRONT PILOT
FORWARD VISIBILITY FROM RCP SOME WHAT RESTRICTED

COLUMBUS TAIL #0849

		T-38 DEBRIEFING SUMMARY TAIL# 0849			
COLUMBUS AFB					
	DATE	SEPT OCT NOV DEC JAN			
		FEB MAR APR MAY JUN JUL			
TOTAL FLIGHT TIME HRS:		120.38333			
		COMPARISON			
		MULTIPLE			
	DISTORTION	IMAGES	REFLECTIONS	HAZE	OVERALL
MUCH BETTER	3	7	6	5	5
BETTER	14	15	26	19	21
SAME	64	79	65	66	60
WORSE	19	6	8	17	16
MUCH WORSE	8	0	2	0	6
TOTAL NUMBER OF REPORTS		107.4			

COLUMBUS TAIL #0849

COMMENTS
A LITTLE DISTORTION IN FRONY CANOPY TOWARDS THE BOTTOM OF THE WINDSCREEN
DISTORTS MOST IMPORTANT PART - LANDING
THE ONLY COMMENT IS THAT THE CANOPY BOW ITSELF SEEMS TO BE THICKER, THUS DISTRACTS
SLIGHTLY FROM FORWARD YISIBILITY. IT ALSO IMPAIRTS AN IRRADESCENT HUE.
SLIGHTLY DARKER THAN NORMAL CANOPY
EASIER TO SEE THROUGH WITH LESS SCRATCHES --IF IT KEEPS LESS SCRATCHES --GREAT
REDUCES GLARE SLIGHTLY
WILL TAKE A LITTLE TO GET USE TO ON FINAL
MUCH BETTER ON SECOND FLIGHT AFTER GETTING EYES ADJUSTED TO DEPTH PERCEPTION
DISTORTION DURING REJOINS AND IN FLARE-THE MIDDLE OF THE WINDSCREEN IS BETTER THAN AVG
BUT AS YOU LOOK TOWARD THE EDGES, PARTICULARLY THE BOTTOM DISTORTION INCREASES
I COUNDN'T DETECT ANY SIGNIFICANT DIFFERENCE
FROM REAR COCKPIT, WITH THE SUN IN OUR 11 O'CLOCK POSITION, DISTINGUISHING LIGHT COLORS
ON THE RUNWAY(i.e. 1ST 1000') WAS YERY DIFFICULT
YISIBILITY WAS EXCEPTIONAL TODAY SO HARD TO TELL ANY DIFFERENCE WHEN THE STUDENT CAN
SEE FOR A CHANGE
CAN SEE SLIGHT RAINBOW OF COLOR ACROSS FRONT WINDSCREEN
HIGH/ LO FORMATION
BACK SEAT IS AFFECTED MORE THAN THE FRONT
FROM BACK SEAT, HAZE HAS WORSE EFFECT WITH TINTED GLASS--NEAR YISION LIMITED
SLIGHT PARALAX FROM THE REAR COCKPIT (NOT SIGNIFICANT)
RESTRICTED YISIBILITY IN REAR COCKPIT DUE TO BIGGER FRAME
COULD NOT TELL ANY DIFFERENCE
LARGE FRAME LIMITED FORWARD YISIBILITY FRONT COCKPIT AND BACK COCKPIT
COULD IMPROVE WINDSHIELD IF "TINT" IS REMOVED
SLIGHT PARALAX FROM REAR SEAT-- NO FACTOR
DISTORTS LANDING PHASE-NEED TO HAVE WHOLE FRONT CANOPY MADE OF SAME GLASS
THE WINDSHIELD SEEMS TO MAGNIFY THE IMAGES SEEN THRU IT-IN FLARE BOTH PILOTS HAD A
TENDENCY TO FLARE HIGH DUE TO THE GROUND APPEARING CLOSER THAN IT NORMALLY WAS
CANOPY APPEARS TO HAVE A "RAINBOW" EFFECT IN CERTAIN SPOTS--UPPER RIGHT CORNER
IN BLAST SHIELD AND NEAR CANOPY BOW IN FRONT COCKPIT
NO CLOUDS ENCOUNTERED-WINDSCREEN PERFORMED IN AN OUTSTANDING MANNER--
NO WIND FELT BY AIRCREW MEMBERS
YERY DIFFICULT TO SEE THROUGH WITH DARK BACKROUND-RAISING DARK YISOR HELPS
WINDSCREEN HAZY AND YERY DIRTY-- REFLECTIONS AND GLARE NOT NOTICED
STUDENT SAYS COLOR APPEARS BLUER THAN OTHERS
THERE IS A NICK IN THE COATING INSIDE THE WINDSCREEN 4 INCH UP FROM RAIL
GIVES EFFECT OF BEING CLOSER THAN YOU ACTUALLY ARE TO THE GROUND-RESULTS IN HIGH FLARES
CAN'T LAND WITH IT
DISTORTION AND GLARE LANDING INTO A LATE EYENING SUN IS TERRIBLE
MY ONLY PROBLEM WITH THE NEW WINDSCREEN IS IT CAUSES SOME PERCEPTION PROBLEMS
AT FIRST, BUT AFTER A FEW OVERHEADS AND LANDINGS, I WAS ABLE TO CORRECT FOR IT.
IF IT PROVIDES BETTER BIRD STRIKE PROTECTION I'M IN FAVOR OF IT. GAUSE X 7125
IT COSTS A LOT OF YIS FROM THE BACK SEAT, FROM THE FRONT SEAT THE LARGER
CANOPY BOW IS ON THE HORIZON (YERY BAD FOR STUD)
ALSO A LOT OF DISTORTION FROM BOTH SEATS.
SORTIE FLOWN DAYTIME SO DISTORTION WOULD NOT BE NOTICED AS MUCH
WORSE THAN NORMAL CANOPY

LAUGHLIN TAIL #13251

		T-38 DEBRIEFING SUMMARY TAIL# 13251			
LAUGHLIN AFB					
	DATE	SEPT OCT NOV DEC JAN FEB MAR			
		APR JUN JUL AUG SEPT			
TOTAL FLIGHT TIME HRS:		444.03333			
		COMPARISON			
		MULTIPLE			
	DISTORTION	IMAGES	REFLECTIONS	HAZE	OVERALL
MUCH BETTER	11	18	17	17	17
BETTER	57	50	69	63	76
SAME	197	281	257	239	182
WORSE	104	27	37	48	99
MUCH WORSE	15	3	2	4	12
TOTAL NUMBER OF REPORTS		381.4			

COMMENTS
OVERALL VISION FROM BACK SEAT WAS HINDERED BY WIDER CANOPY BOW
SOME DISTORTION WAS NOTICED ON FINAL FROM BACK SEAT
FRONT CANOPY BOW WAS THICKER THAN NORMAL- THIS REDUCED SOME VISION
CANOPY BOW IS THICKER - TRY TO MAKE THINNER
CANOPY BOW TOO BIG
IN FORMATION JET IN LOWER PART OF WINDSCREEN WAS BLURRED
FRONT CANOPY BOW IS THICKER MAKING VIEW A LITTLE MORE OBSCURVED
OVERALL SHIELD GIVES A BETTER TINTED IMAGE, VERY EASY TO SEE OUT OF
NO DIFFERENCE NOTED
CANOPY BOW IS SLIGHTLY LARGER THUS RESTRICTING VISION MORE
NO VISUAL PROBLEMS NOTED-WE LIKED THE NEW CANOPY MAINLY BECAUSE
IT WAS CLEAN AND LESS SCRATCHED
DEPTH PERCEPTION CAUSES RUNWAY TO APPEAR CLOSER THAN NORMAL
DEPTH PERCEPTION IS WORSE
MOUNTING HARDWARE ABOVE FCP GLARE SHIELD REDUCES VISION FROM RCP
BETTER SUNSCREEN-- TINT GOOD IDEA
THICKNESS OF CANOPY BOW LIMITS VISION FOR IP SIGNIFICANTLY
CUTS A LITTLE BIT OF FORWARD VISIBILITY
SOME DISTORTION NOTED IN CANOPY BOW AREA
W/ MOISTURE ON THE WINDSCREEN, GLARE WAS A PROBLEM(ACTUALLY PRETTY SEVERE)
CANOPY BOW AT TOP OF FORWARD WINDSCREEN APPEARS WIDER & RESTRICTS BACK SEAT VISION
STUDENT DISLIKED WIDER CANOPY F/C/P INSTRUMENTS TEND TO REFLECT AND
DISTRACT FROM IP'S VIEW--MAY BE A PROBLEM AT NIGHT
F/C/P OCCUPANT SAYS CANOPY BOW IS NOTICEABLY LARGER
CANOPY BOW SEEMS THICKER
DISTORTION MAINLY AT SIDES OF CANOPY JUST ABOVE WHERE WINDSCREEN MEETS NOSE
WINDSCREEN SEEMS TO MAGNIFY, NOT AS CLEAR
BOTTOM RIGHT HAND SIDE ALONG RAIL, GIVES A RAINBOW EFFECT DURING FLIGHT
RCP THICK CANOPY BOW BLOCKS VISION
DECREASED VISION FROM BOTH COCKPITS BECAUSE OF LARGER CANOPY BOX
REAR SEATER - WORSE VISION DUE TO BOX ON WINDSHIELD BOW
VISIBILITY FROM THE BACK SEAT OVERALL LESS BECAUSE THE CANOPY SEEMS NARROWER
CANOPY BOW TOO BULKY, REDUCES VISIBILITY
THE FCP BOW RESTRICTS THE RCP OCCUPANTS FORWARD VISIBILITY DURING APPROACH AND
LANDING PHASE. THIS IS ESPECIALLY EVIDENT DURING NO FLAP APPROACHES.
THERE IS BETTER VISIBILITY THROUGH THE FCP CANOPY
WORSE BECAUSE CANOPY BOW IS BIGGER
IT'S NICE BECAUSE IT IS CLEANER (LESS SCRATCHED) THAN THE REGULAR CANOPIES
THE CANOPY BOW IS TO THICK AND MAKES IT HARDER TO SEE RUNWAY FROM THE REAR SEAT
NO VISIBILITY CHANGE--A LITTLE DARKER IN COLOR
DECREASED REAR SEAT VISIBILITY ON NO FLAP LANDINGS
NO REAL PROBLEM WITH WINDSCREEN
NOTICED NO DIFFERENCE BETWEEN THIS WINDSCREEN AND STANDARD WINDSCREEN
NO SCRATCHES
GLASS SEEMS TINTED
VERY GLAREY -- HARD TOO SEE
BACKSEAT VISION REAR COCKPIT - WORSE
LIP ON GLARE SHIELD REDUCES REAR COCKPIT VISION
DISTORTION DURING NO FLAP LANDINGS IS NOTEWORTHY
SAME AS OTHER -- NO DIFFERENCE
NOTED GLARE- DOUBLE IMAGES ESPECIALLY WITH DIRECT SUNSHINE

CANOPY BOW TOO THICK
NICE AND CLEAR
STUDENT SAID LIP RESTRICTED VISIBILITY SOMEWHAT
APPEARS TO HAVE SLIGHTLY YELLOWISH TINT AND DISTORTION IN THE CORNERS
NEITHER OF US COULD TELL ANY DIFFERENCE
DISTORTION IN LOWER CORNER AREA OF FRONT WINDSCREEN MUCH WORSE THAN NORMAL.
CLEARER BETTER VIEWING NO SCRATCHES
THICKER FCP CANOPY BOW RESTRICTS VISION MORE THAN EXSISTING CANOPY.
CANOPY BOW IS SO LARGE IT CUTS FIELD OF VISION DURING FORMATION FLIGHT.
DISTORTION AROUND EDGES
BOTH CP'S COMPLAINED OF WIDER CANOPY BOW DISTRACTION IN THE LANDING PHASE.
MUCH LESS VISIBILITY DUE TO LARGER CANOPY BOW.
CANOPY BOW SEEMS LARGER BLOCKS A LITTLE R/C/P VISION
CANOPY BOW TOO LARGE
COULD NOT SEE OUT CANOPY BOW IS TOO LARGE
REAR COCKPIT VISIBILITY MUCH WORSE DUE TO THE PARALAX EFFECT FROM
GLARE SHIELD TO WINDSCREEN
LARGE CANOPY BOW REDUCES VISIBILITY FROM BACK SEAT SLIGHTLY.
I LIKE THE TINT, HOWEVER THE LARGER CANOPY BOW OBSCURES FORWARD VISION
ESPECIALLY FROM THE REAR COCKPIT.
FRONT COCKPIT MOUNTING HARDWARE IS BULKY AND REDUCES VIS FROM REAR COCKPIT
TOUGH TO SEE WITH THICKER GLASS. MORE DISTORTION ESPECIALLY FOR THE I.P.
IN THE BACK WHO LOOKS DOWN THE SIDE BY THE STUDENT PILOTS HEAD.
FROM BACKSEAT DISTORTION IS SLIGHTLY WORSE AND CLARITY SLIGHTLY IMPAIRED
CAN'T SEE OUT OF REAR COCKPIT DUE TO CANOPY BOW.
CANOPY BOW MUCH LARGER DECREASING R/C/P VISIBILITY
AIRCRAFT VISIBILITY IS RELATIVELY BETTER
SEEMS TO HAVE A SIGNIFICALLY LARGER CANOPY BOW --RESTRICTING VISION IN FORMATION
CANOPY BOW TOO BIG AT HIGHER PITCH ATTITUDES, LOWER PART OF CANOPY CAUSED
DOUBLE IMAGES AND GREATER DISTORTION.
CANOPY BOW TOO BIG
CANOPY BOW IS TOO THICK LIMITS PILOTS VISIBILITY DIRECTLY IN FRONT OF HIS FACE
I LIKE THE TINT, HOWEVER THE CANOPY BOW DECREASES FORWARD VISIBILITY
FROM THE REAR COCKPIT.
TOO LARGE OF CANOPY BOW
NOTHING NEGATIVE TO NOTE.
THE DISTORTION CAUSES THE AIRCRAFT YOU ARE REJOINING ON TO HAVE TWO RELATIVE
SIZES AT THE SAME TIME. I.E. REJOINS ARE EXTREMELY TOUGH. IT ALSO CAUSES PROBLEMS
FOR LANDING--- I'D LOVE TO TELL YOU ABOUT IT IN PERSON . MAJ P. RODNEY X5383
DOWNWARD ANGLE-- LOOKS CLOSER THAN NORMAL (ACTUALLY HIGHER THAN AIRCRAFT IS)
LARGE FRONT CANOPY BOW WHEN LDG FROM BACK SEAT
BOTTOM PART OF WINDSCREEN HAS DISTORTION AND REFLECTION (IP IN FRONT SEAT)
DURING PERIODS CLOSE TO SUNSET VISIBILITY WAS REDUCED DUE TO REFLECTION.
VFR CONDITIONS THROUGHOUT SORTIE
FRONT SEAT FINE--- BACK SEAT WORSE
CANOPY BOW WAS LARGER THAN NORMAL BLOCKING THE VIEW
FROM BACKSEAT DISTORTION AROUND EDGES FRONTSEAT NORMAL
DISTORTION MAINLY APPERANT LOW TO THE GROUND DURING LANDING PHASE
EXTRA THICK CANOPY BOW RESTRICTS FORWARD VISIBILITY FROM REAR COCKPIT AND
HAMPERS LANDINGS
DISTORTION NOTED DURING TURNING REJOINS (FRONT COCKPIT)
ALSO NOTED SLIGHT DIFFICULTY IN DEPTH PERCEPTION IN LANDING PHASE

CAUSED MORE DISTORTION AROUND CANOPY BOW
CANOPY BOW ITSELF IS LARGER AND OBSTRUCTS VIEW
LARGER CANOPY BOW OBSTRUCTS VISIBILITY
CANOPY BOW RESTRICTS VISION
SLIGHTLY DISTORTS VIEW FROM RCP
VISIBILITY DECREASES WITH BAR ON CANOPY BOW
CAUSES PRISM IMAGES AROUND CURVATURES MUCH WORSE THAN OTHER WINDSCREEN
CANOPY BOW IS TOO THICK
NICE
LESS VISIBILITY FROM WIDER CANOPY RAIL ALL AROUND
MUCH HARDER TO CLEAR FROM REAR C/P WITH WIDER CANOPY BOWS
A LOT OF DISTORTION AROUND THE BASE
FROM THE BACK COCKPIT THE IMAGE I RECEIVED THROUGH THE FRONT WINDSCREEN WAS A
MAGNIFICATION OF WHAT I WAS SEEING THROUGH THE CANOPY AROUND IT.
THE RESULT WHILE TRYING TO LAND WAS TWO COMPLETELY DIFFERENT PICTURES OF MY
HEIGHT TOUCHDOWN. APPARENTLY THE WINDSCREEN IMAGE WAS INCORRECT SINCE I FLARED
HIGH WHILE REFERENCING THE IMAGE IT WAS TRANSMITTING
REFRACTION IS INACCEPTABLE
COMBINED EFFECT OF BOTH WINDSHIELDS LARGER CANOPY BOWS SIGNIFICANTLY
REDUCES VISIBILITY FROM RCP
THE SHIELD MAGNIFIES THE GROUND MAKING YOU FEEL HIGHER THAN YOU ARE CAUSING
HIGH FINALS HIGH FLARES. AIRCRAFT SEEM CLOSER THEN THEY ARE
REAR SEAT VISIBILITY OBSTRUCTED BY EXTRA THICK CANOPY BOW
REDUCED VISIBILITY
WIDER CANOPY BOW LESSENS ALREADY LIMITED VISIBILITY FROM THE BACK COCKPIT
DISTORTION APPEARS IN LOWER CORNERS OF FRONT WINDSCREEN AS VIEWED FROM THE
REAR COCKPIT. DISTORTION PUTS CURVES (BENDS) IN STRAIGHT LINES
CANOPY MADE RUNWAY APPEAR APPROX 5-7FT CLOSER DURING FLARE PORTION OF LANDING
THIS IS A COMPARISON TO OTHER T-38 CANOPIES AND SIMILAR LANDINGS
MOUNTING HARDWARE BETWEEN FCP & RCP IS TOO BULKY
REDUCES RCP VIS DURING LANDINGS, ALSO FCP BOW RIGGING REDUCES VIS
RIGGING & HARDWARE ON FCP BOW AND RCP SHIELD REDUCES RCP VIS IN LANDINGS
ALMOST IMPOSSIBLE TO SEE FROM R/C/P
CANOPY BOW OBSTRUCTS VIS ALMOST COMPLETELY TINT ALSO IMPARES VISIBILITY
VISIBILITY FROM REAR COCKPIT SEVERELY LIMITED WITH ENLARGED CANOPY BOW
RCP EXTRA THICK CANOPY BOW RESTRICTS PILOTS VISION
FCP LOW EDGE OF CANOPY MAGNIFIES GROUND DISTORTS GROUND AND IS HAZY
CANOPY BOW IS TOO THICK ESPECIALLY IN FORMATION
GOOD CLEAN VISION
ENLARGED CANOPY FRAME RESTRICTS VIEW
DIFFICULT TO LAND FROM REAR SEAT DUE TO LARGE CANOPY BOW
HAS SOME REFLECTION AND DISTORTION
DISTORTION IS A FACTOR F/C/P
IN ADDITION LARGE SIZE CANOPY BOW REDUCES VISIBILITY
FRONT GLARESHIELD SLIGHTLY DISTORTS THE VIEW FROM REAR COCKPIT
(MORE THAN NORMAL) BUT DOESN'T TAKE MUCH GETTING USED TO.
REDUCED FORWARD VISIBILITY FOR REAR SEATER
CANOPY BOW MUCH THICKER LESS ARCH TO SEE OUT OF FROM THE REAR COCKPIT
CANOPY BOW IS TOO BIG
BOW TOO BIG
GREAT
BETTER

LAUGHLIN TAIL #13251

BEAUTIFUL
CANOPY BOW IS TOO LARGE
LARGE CANOPY BOW GREATLY RESTRICTS R/C/P VIS
ENLARGED CANOPY BOW GREATLY DECREASES R/C/P FORWARD VISIBILITY
BOW IS TOO BIG
GREAT
BOW IS TOO LARGE

APPENDIX F

TEST PLAN - BIRD IMPACT

TEST PLAN - BIRD IMPACT
T-38 ALTERNATIVE TRANSPARENCIES

PPG INDUSTRIES, INC.
AIRCRAFT PRODUCTS
TECHNOLOGY DEVELOPMENT
HUNTSVILLE, ALABAMA

PREPARED BY: J. W. Myers

J. W. Myers
Project Engineer

5/16/85
Date

PPG Industries, Inc.

APPROVALS

APPROVED BY: W. F. Rothe 5/16/85

W. F. Rothe, Manager
New Products Design and Development

Date

APPROVED BY: S. D. Stewart 5/16/85

S. D. Stewart
Sr. Design Engineer

Date

TABLE OF CONTENTS

1.0 SCOPE

This test plan outlines procedures required to determine the effects of bird impacts on the T-38 student windshield system and instructor windshield system supplied by PPG Industries under contract F33615-81-C-3403 for prototype and flight quality phases of the program (Reference 4.3.2, 4.3.5, and 4.4.5 - SOW).

2.0 REQUIREMENTS

The requirement of this test plan is to verify that the collision of a 4 pound bird on the student windshield system and the instructor windshield system will not cause catastropic damage to the T-38 aircraft, when impacted at the required levels of protection and that the windshields pass all the requirements of the acceptance limits. (Reference Paragraph 12.0 Acceptance Limits).

3.0 PRE-PROTOTYPE TEST HISTORY

During the course of the pre-prototype design development, PPG Industries has conducted testing as necessary to determine and confirm the bird impact resistance capability of transparency design configurations and frame aft arch reinforcement techniques. This testing included static structual testing and dynamic impact testing of components or assemblies which were conducted by PPG at PPG supplied or subcontracted facilities. During the pre-prototype effort, PPG has fabricated and bird impact tested various transparency cross-sections and aft arch reinforcement techniques in an effort to determine the most viable approach. Following are the major pre-prototype test activities:

3.1 Analysis Of Bolt Hole Size And Spacing

These strain gauged beam samples with various bolt hole sizes and spacings were loaded in bending to determine the effects of hole sizes, spacing and bolt torque.

3.2 Cast 610 Nickel-Chromium Alloy Material Properties

These test determined the material properties of the first aft arch reinforcement design for conversion of strain data and for input into the "MAGNA" analysis. The values provided by the manufacturer were ±25%, and thus actual values had to be generated.

3.3 Bird Impact Testing - October, 1982

Two (2) monolithic polycarbonate panels of the same thickness (0.600 inch) as the polycarbonate in the liner faced design were fabricated, fitted and mounted to windshield frames for bird impact testing at the National Research Council (NRC), Ottawa, Canada in October, 1982. Seven (7) impacts were made during the week long effort. The purpose of these

3.3 Bird Impact Testing - October, 1982 (Continued)

tests was to evaluate the cast 610 nickel-chromium alloy aft arch reinforcement, the method of edge attachment, and to collect data for "MAGNA" comparison. The first monolithic transparency with the cast 610 nickel chromium alloy aft arch reinforcement was impacted at 209 knots and resulted in an unexpected catastrophic failure. The second unit was then impacted in the same aft arch location at 200 and 253 knots with no damage to the transparency but permanent deformation to the cast 610 nickel-chromium alloy aft arch reinforcement. Four additional sill impacts were taken, two on the right sill at 249 and 395 knots, and two on the left sill at 299 and 406 knots. The transparency had no damage, but both the frame and the cast 610 nickel-chromium alloy aft arch reinforcement was severely damaged.

3.4 High Speed Unnotched Izod Testing

Testing, to determine if there was a difference in the impact resistant properties of the polycarbonate in the first two windshields, which were bird impact tested. This test was necessary due to the apparent difference of the impact resistance of the two panels at low speeds.

3.5 Bonding Tests of Strain Gauge Bond Strength

Tests to determine if strain gauges would bond to the inboard coating and if the gauge results compared to gauges bonded directly to uncoated polycarbonate.

3.6 Air Cannon Impact Tests

Tests to determine if strain gauges bonded to the inboard coating will provide the same results as gauges bonded to the polycarbonate under impact conditions. The test was also used to see if a gauge bonded directly beneath the impact point causes brittle failure.

3.6 Air Cannon Impact Tests (Continued)

As a result of the performance and damage assessment from this series of testing, it was determined that a different aft arch reinforcement system was required. A two prong approach was taken; PPG designed a machined aft arch reinforcement of high strength Unitemp 718 and subcontracted The University of Dayton to design and fabricate two (2) Kevlar®-epoxy composite aft arch reinforcements.

3.7 Composite Material Properties

These tests were necessary to establish material properties and for the conversion of strain gauge values to stress values and for use in "MAGNA".

3.8 Machined Part Material Properties

These tests were necessary to establish material properties and for the conversion of strain gauge values to stress values and for use in "MAGNA".

3.9 Bird Impact Testing - May, 1983

In the second bird impact test series, two (2) windshields (0.600-inch thick monolithic polycarbonate) mounted into frames, strain gauged, and having Kevlar®-epoxy composite aft arch reinforcements, were tested in May, 1983. The first monolithic windshield system was bird impacted at a speed of 208 knots at the aft arch centerline location. Catastrophic failure of the monolithic windshield occurred. The second monolithic windshield system was impacted in a step-wise fashion. This monolithic windshield passed at 208 and 250 knots; then failed at 306 knots. Again, catastrophic failure occurred.

3.10 Air Cannon Impact Tests

Due to the failures in the May, 1983 bird impact testing, the air cannon impact tests were performed again. These tests indicated that the adhesive used to bond the strain gauges to the polycarbonate may have caused stress risers and as a result, caused failure of the unit.

3.11 Bird Impact Testing - September, 1983

In the third bird impact test series, three (3) windshields were fabricated, mounted in frames, strain gauged on the frame only and prepared for bird impact testing. Two of these windshields were 0.600-inch thick monolithic polycarbonate and one was a 0.375/0.187 PPG 112® polycarbonate laminate. The first monolithic windshield with 4 4130 chrome-moly 1.500-inch x 1.500 inch by .125 inch thick angles for aft arch reinforcement had catastrophic failure at 379 knots. Due to this failure and the failure of all previous monolithic parts, the second monolithic windshield was not tested. The laminated cross section with the 4130 chrome-moly seamless tubing aft arch reinforcement and two (2) 0.090 thick x 1.500-inch x 1.500-inch angles of 4130 chrome-moly on the aft side of the arch, passed a 398 knot bird impact. It was decided after this series of testing that all future windshields would be laminated cross sections.

3.12 Bird Impact Testing - Febraury, 1984

In the fourth bird impact test series, three (3) laminates were fabricated, mounted in frames, strain gauged on the aft arch reinforcement only and prepared for bird impact testing. The purpose of this testing was as follows:

3.12 Bird Impact Testing - February, 1984

1. Generate bird impact stress-strain and deflection data of the 4130 chrome-moly seamless tubing aft arch reinforcement for use in designing a Kevlar® epoxy composite aft arch reinforcement.
2. Perform a verification bird impact of the laminate cross section passed in September, 1983 testing.
3. Perform bird impact testing on two (2) thinner cross sections in an effort to reduce weight and determine the minimum thickness that would withstand the bird impact.

The results of the verification bird impact of the 0.375/0.187 PPG 112® laminate with 4130 chrome-moly seamless tubing aft arch reinforcement was favorable at a speed of 396 knots. The two (2) other lighter cross sections of 0.250/0.250 and 0.187/0.187 PPG 112® laminates failed at 403 and 396 knots. Although the two (2) thin laminates failed, they did show enough promise for further redesign.

3.13 Bird Impact - Testing July, 1984

In the fifth bird impact test series, three (3) laminates were prepared for bird impact testing. The purpose for this testing was as follows:

1. Perform bird impact testing on 0.375/0.187 PPG 112® cross section with a Kevlar® epoxy composite aft arch reinforcement for comparison to the same cross section with the 4130 chrome-moly seamless tubing aft arch reinforcement.
2. Perform bird impact testing on redesigned 0.250/0.250 and 0.187/0.187 PPG 112® laminates.
3. Generate stress-strain and deflection data for use in design modifications to the composite Kevlar® epoxy aft arch reinforcement.

3.13 Bird Impact - Testing July, 1984 (Continued)

The Kevlar®epoxy composite aft arch reinforced frame with the 0.375/0.187 PPG 112 R laminate was bird impacted at 404 knots and passed with no damage to the laminate. The redesigned 0.250/0.250 PPG 112® laminate was bird impacted at 403 knots with the laminate passing but severe damage to the frame.

The redesigned 0.187/0.187 PPG 112®laminate was bird impacted at 400 knots and the laminate failed directly above the inboard retainer. There was severe deflection and permanent deformation of the aft arch.

3.14 Bird Impact Testing - October, 1984

In the sixth bird impact test series, performed at PPG's facility in Huntsville, Alabama, three (3) laminates were again prepared for bird impact testing. The purpose for this testing was as follows:

1. Verification of facility and set-up (timing lights, event marker, high speed film, set-up, etc.).
2. Perform bird impact testing on two (2) different designs of Kevlar®epoxy composite aft arch reinforcement cross sections with 0.187/0.187 PPG 112®laminate.

A reject part was bird impacted at 401 knots and the laminate passed. Several adjustments were made in the overall set-up to agree with required test conditions. The first 0.187/0.187 PPG 112®laminate was bird impacted at 401 knots and failed by pulling through the aft arch bolts. This unit had a stiff Kevlar®epoxy composite reinforcement.

3.13 Bird Impact Testing - October 1984

The second 0.187/0.187 PPG 112® laminate had 1-inch diameter washers under the bolt heads to try and prevent pull-through. This unit was reinforced with a more flexible Kevlar® epoxy composite aft arch reinforcement. At a speed of 406 knots, the laminate failed but the bolts did not pull through the polycarbonate. The polycarbonate failed from bolt hole-to-bolt hole due to being overpowered.

4.0 TEST ITEM DESCRIPTION STUDENT WINDSHIELD

After extensive testing in the pre-prototype stage one cross section has been established for the remainder of the program. This cross section is depicted in Figure 1 and consists of the following. The aft arch reinforcement of the magnesium frame will be KEVLAR/FIBERGLASS HYBRID composite bonded directly to the fame. The windshield consist of an outboard ply of .375 aircraft grade polycarbonate with an outboard liner of .03 thick PPG 5300 material. This ply is laminated to an inboard ply of .187 aircraft grade polycarbonate with an inboard coating of .003 thick PPG 8500 material. The interlayer in this laminate is .060 thick PPG 112 material. At the aft arch of the windshield a .160 inch thick HEXCEL FIBERGLASS outboard retainer and a .035 inch thick stainless steel inboard retainer are bonded to the laminate with URALANE 5738. To complete the assembly a wedge of GILFAB FIBERGLASS is bonded to the aft arch with URALANE 5738. This wedge serves to match the contour of the windshield and the frame. The nose fairing and sill fairings are fabricated from 6061 T6 aluminum .100 inch thick. The windshield is bolted to the frame with #10 aircraft bolts at the sills and 1/4" aircraft bolts in the aft arch. To seal the outside of the windshield to the aft arch and edge fairings URETHANE UR 2102 is used. This material provides a smooth transition from the windshield surface to the fairing.

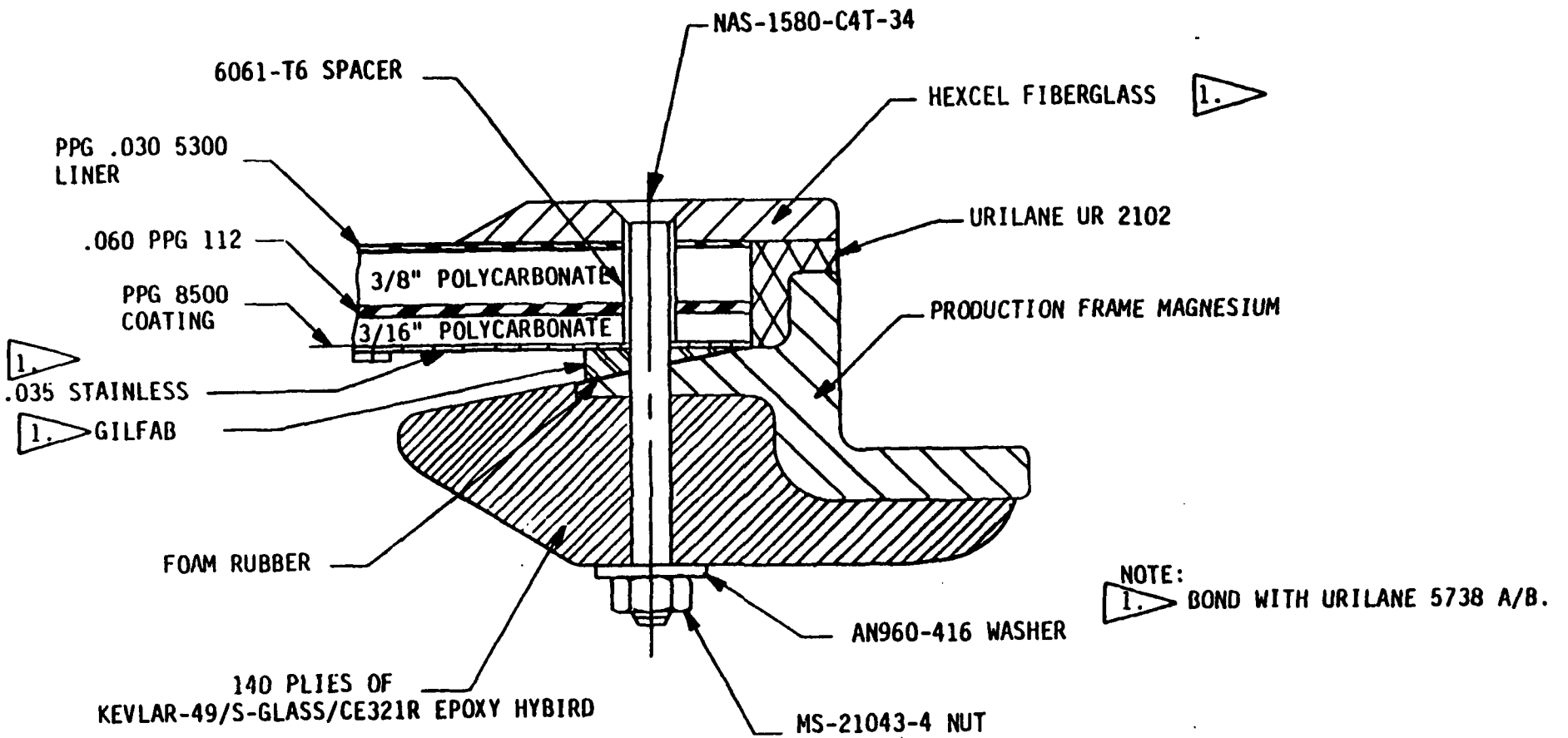

NAS-1580-C4T-34
6061-T6 SPACER
HEXCEL FIBERGLASS
1.
PPG .030 5300
LINER
URILANE UR 2102
.060 PPG 112
3/8" POLYCARBONATE
PPG 8500
COATING
3/16" POLYCARBONATE
PRODUCTION FRAME MAGNESIUM
1.
.035 STAINLESS
1.
GILFAB
FOAM RUBBER
NOTE:
1. BOND WITH URILANE 5738 A/B.
AN960-416 WASHER
140 PLIES OF
KEVLAR-49/S-GLASS/CE321R EPOXY HYBIRD
MS-21043-4 NUT

FIGURE 1

5.0 PROTOTYPE TESTING STUDENT WINDSHIELD

Prototype design testing will be limited to the windshield system design described in Section 4.0. Although minor design changes may be made, it is desirable not to make any changes in the prototype design. All prototype bird impact testing will use the rigid support frame that has been constructed by PPG for mounting and securing the windshield frame (Reference Figures 2 and 3). This support system facilitates easy access to the transparency mounting system, greater flexibility of camera location, and faster change out from one target to the next. Bird impacting will consist of two impacts on each of five (5) windshield systems, the first at 400 knots, with a secondary impact at 130 knots (Reference 4.2.1 - SOW). This represents ten (10) impacts on five (5) windshields shown on Table I. Provisions have been made for a post pressure/thermal impact. The impacts will be made at all four (4) of the required locations shown in Figure 4. Due to the knowledge gained in pre-prototype testing, PPG recognizes that possibly more than one of the impact locations may be tested on any single windshield. This deviation from the contract would only be implimented by agreement of both PPG and WPAFB.

Upon the approved completion of the prototype testing the next phase of testing would commence.

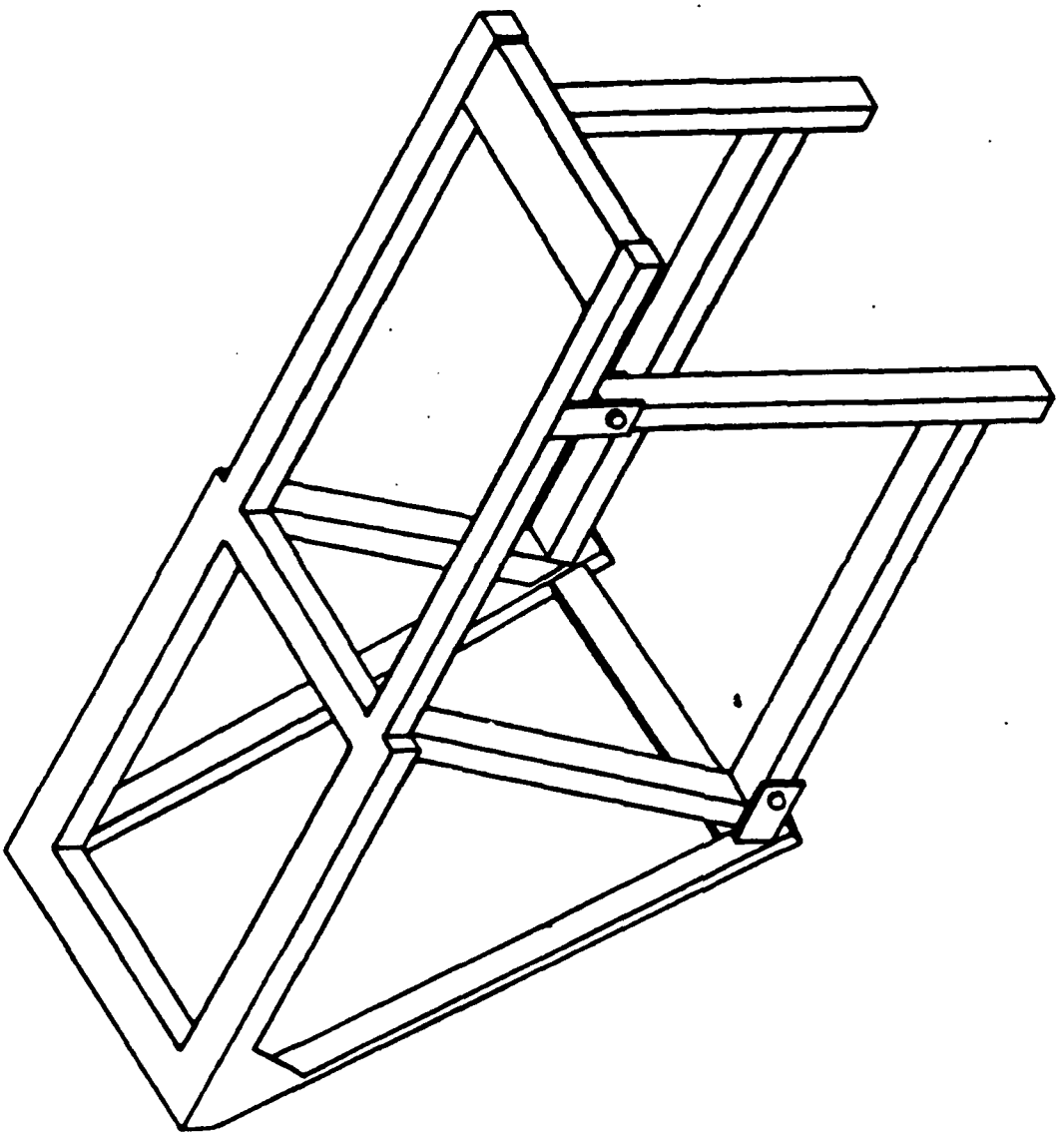


FIGURE 2

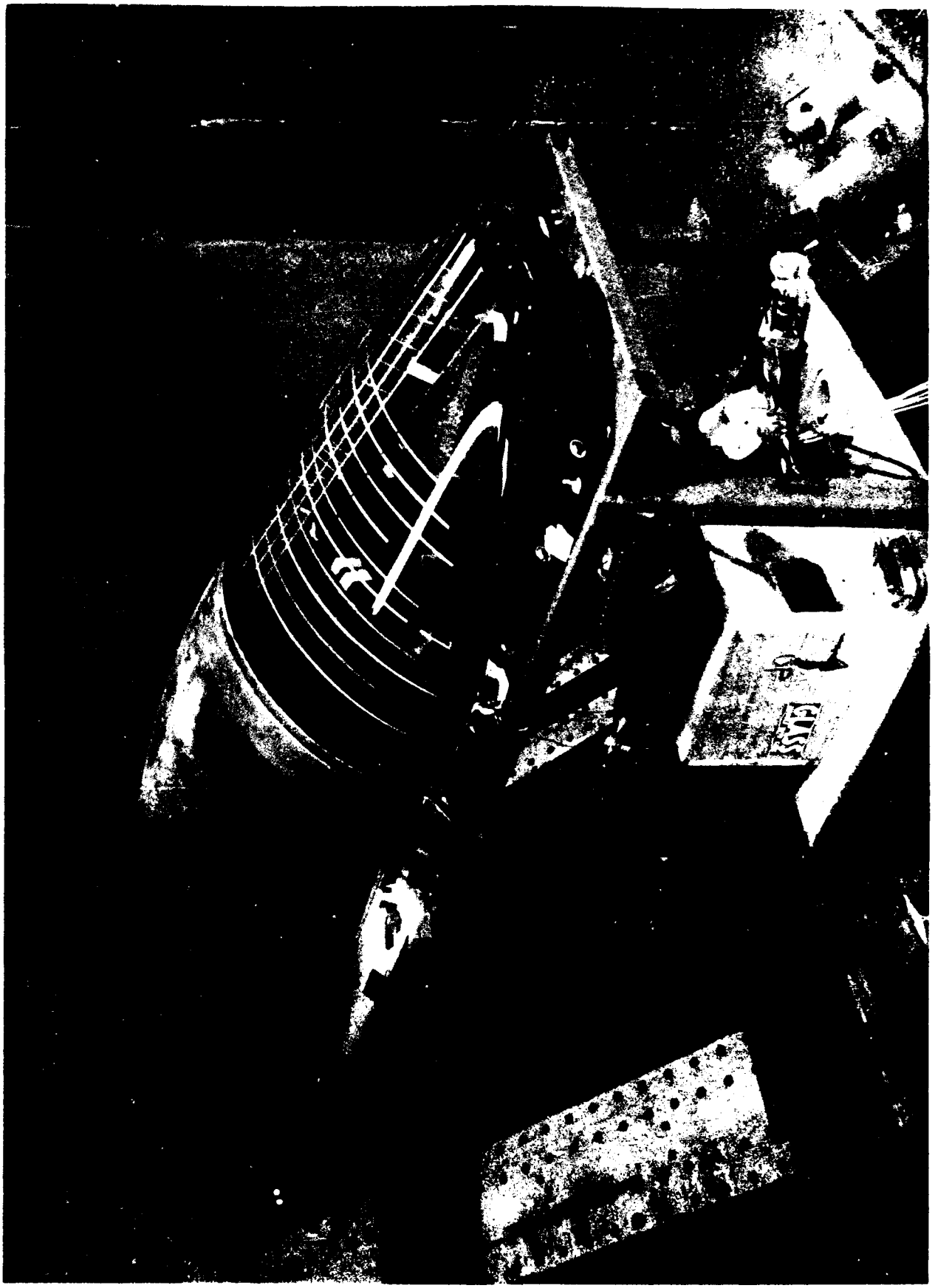


FIGURE 3 T-38 TEST SET-UP.

Prototype Testing Student Windshield

TABLE I

PROTOTYPE STUDENT WINDSHIELD BIRD IMPACT TESTING

SHOT NO.	WINDSHIELD NO.	SPEED (KT)	LOCATION	TEMPERATURE	REMARKS
1	1	400	AFT	HIGH	REQUIRED PROTECTION
2	1	130	AFT	ROOM	REQUIED PROTECTION
3	2	400	AFT	LOW	REQUIRED PROTECTION
4	2	130	AFT	ROOM	REQUIRED PROTECTION
5	3	400	SILL	ROOM	REQUIRED PROTECTION
6	3	130	SILL	ROOM	REQUIRED PROTECTION
7	4	400	FRONT	ROOM	REQUIRED PROTECTION
8	4	130	FRONT	ROOM	REQUIRED PROTECTION
9	5	400	CENTER	ROOM	REQUIED PROTECTION
10	5	130	CENTER	ROOM	REQUIRED PROTECTION
11	6	400	WORST	WORST	POST PRESSURE/ THERMAL

All impact angles are 27.5 degrees measured from horizontal.
(Reference 4.2.1 - SOW)

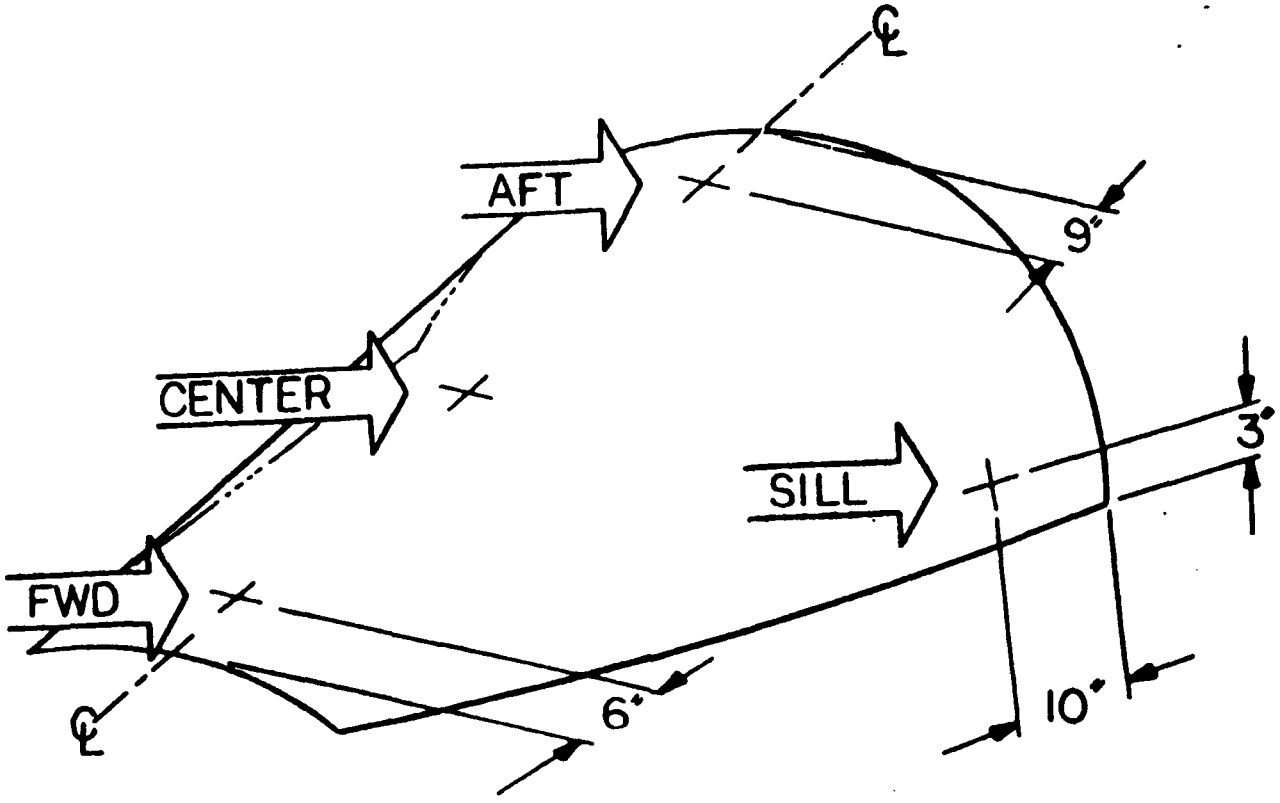


FIGURE 4

STUDENT WINDSHIELD
BIRD IMPACT LOCATIONS

6.0 FLIGHT QUALITY TESTING STUDENT WINDSHIELD

Flight quality testing will be conducted on the final design configuration determined during the prototype testing. Flight quality windshields will then be representative of production parts. The flight quality testing is the final certification of the design and of the manufacturing processes.

All flight quality bird impact testing will be performed in an actual fuselage supplied to PPG by WPAFB. Bird impact testing will consist of two impacts on each of three (3) windshield systems . The first at 400 knots, with a secondary impact at 130 knots (Reference 4.2.1 - SOW). The impact locations of the test will be determined from the prototype testing and be a worst case test. Provisions again have been made for a post pressure/thermal impact. This represents six (6) impacts on three (3) windshields as shown on Table II. One spare windshield system will allow for additional impact testing if required.

Upon satisfactory completion of the flight quality testing (documented air-worthiness) the windshield system would then be ready for installation for Developmental/Operational Test and Evaluation (D/OT and E).

Flight Quality Testing Student Windshield

TABLE II

FLIGHT QUALITY STUDENT WINDSHIELD

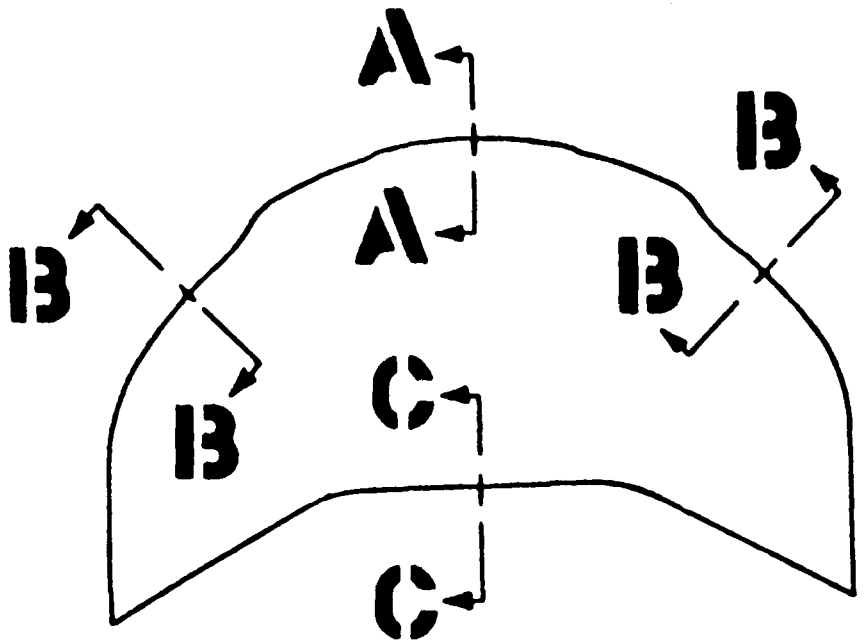
BIRD IMPACT QUALIFICATION

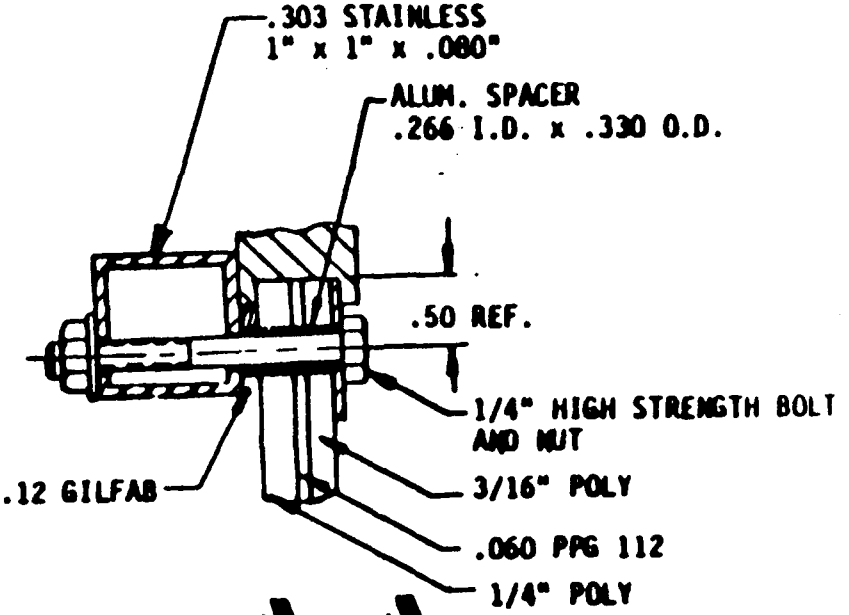
SHOT NO.	WINDSHIELD NO.	SPEED (KT)	LOCATION	TEMPERATURE	REMARKS
1	1	400	WORST	ROOM	REQUIRED PROTECTION
2	1	130	SAME AS ABOVE	ROOM	REQUIRED PROTECTION
3	2	400	WORST	LOW	REQUIRED PROTECTION
4	2	130	SAME AS ABOVE	ROOM	REQUIRED PROTECTION
5	3	400	WORST	HIGH	REQUIRED PROTECTION
6	3	130	SAME AS ABOVE	ROOM	REQUIED PROTECTION
?	4	(SPARE AS NEEDED)			
?	5	400	WORST	WORST	POST-THERMAL/ PRESSURE

All impact angles are 27.5 degrees measured from horizontal.
(Reference 4.2.1 - SOW)

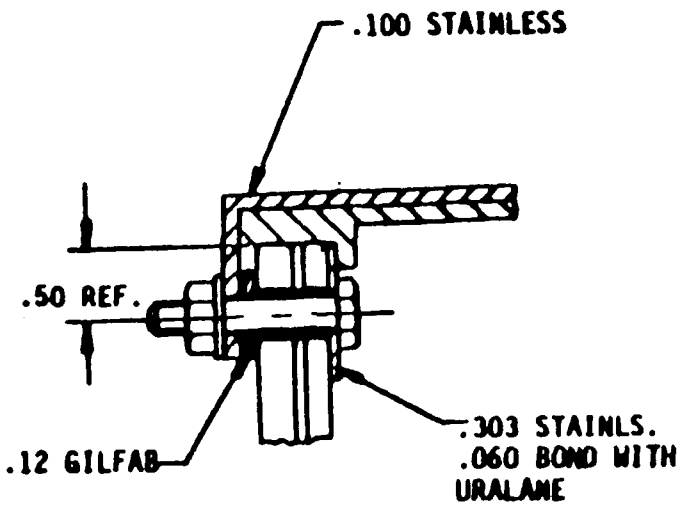
7.0 TEST ITEM DESCRIPTION INSTRUCTOR WINDSHIELD

Again after extensive testing in the pre-prototype stage one cross section has been established for the remainder of the program. This cross section is depicted in Figure 5 and consists of the following. A forward ply of .250 inch thick polycarbonate with 8500 coating on the outboard surface. An aft ply of .187 inch thick polycarbonate with 8500 coating on the outboard surface. These two plies are laminated with .060 inch thick PPG 112 interlayer. As an add on a .100 inch thick stainless retainer has been added to the forward side and a .060 inch thick stainless strap to the aft. Between the attachment points for the braceing rods the flat retainer has been replaced with a 1 inch x 1 inch x .080 inch thick stainless tube for added stiffness. All of the stainless material is bolted to the windshield with .250 inch high strength bolts. It is also bolted to the aluminum casting and to the braceing rods. the original braceing rods have been replaced with .090 inch thick x .750 inch wide tool steel with the ends hardened to a Rockwell hardness of 55 to 60.

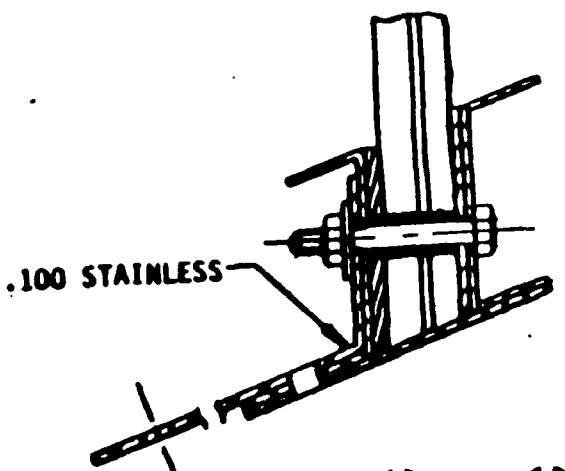




SECTION A-A



SECTION B-B



SECTION C-C

FIGURE 5

8.0 FLIGHT QUALITY TESTING INSTRUCTOR WINDSHIELD

All flight quality bird impact testing will be performed in an actual fuselage supplied to PPG by WPAFB. Bird impact testing will consist of a single impact on each of the two windshield systems at 250 knots and at ambient temperature. Provisions have been made for a post pressure/thermal impact. This represents three (3) impacts located by Figure 6 on three (3) windshield systems as shown on Table III. This is an exception to the SOW 4.2.1. We propose to eliminate the requirement of high and low temperature testing since this windshield system would be in an ambient atmosphere.

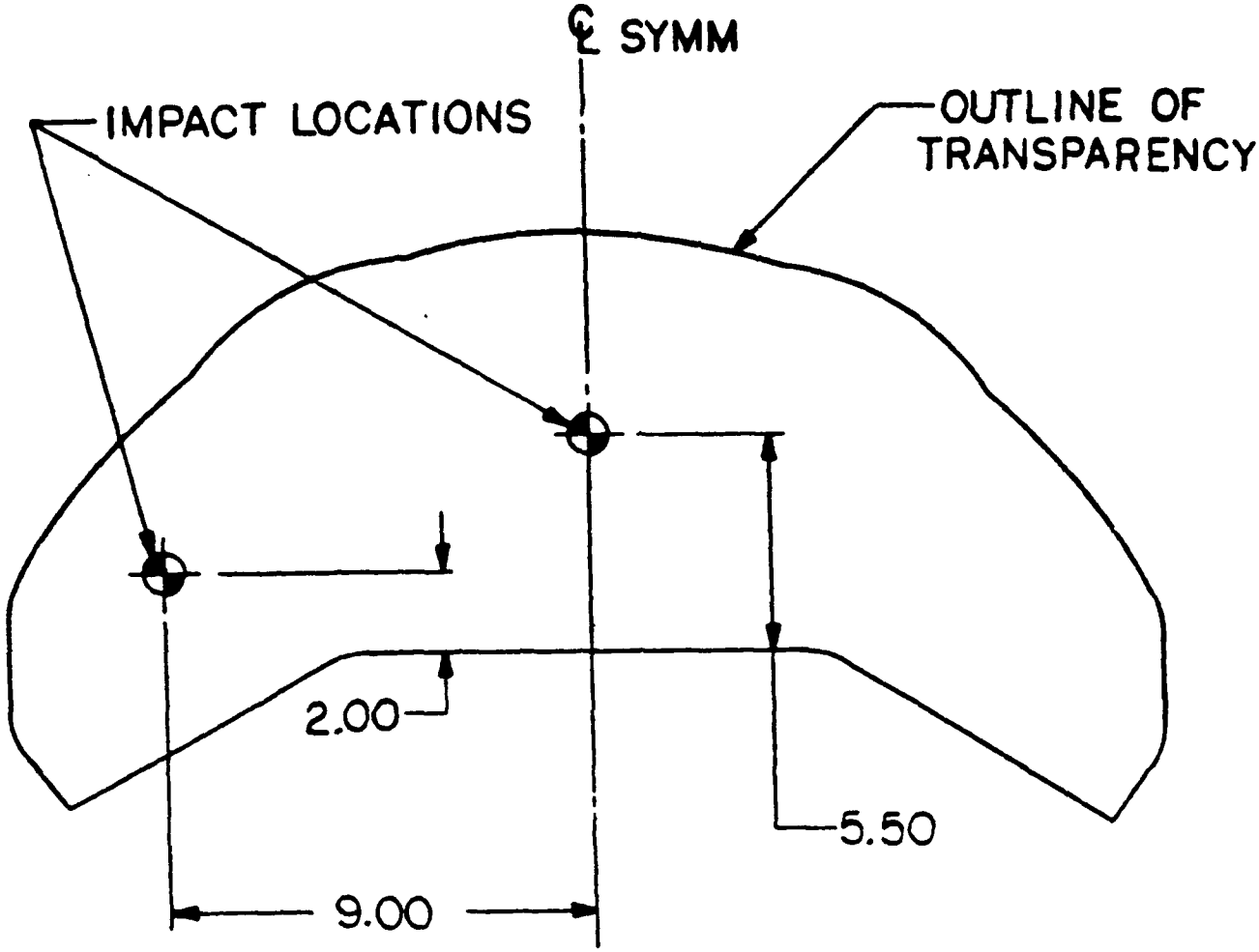


FIGURE 6

INSTRUCTOR WINDSHIELD
BIRD IMPACT LOCATIONS

Flight Quality Testing Instructor

TABLE III

FLIGHT QUALITY INSTRUCTOR WINDSHIELD

BIRD IMPACT QUALIFICATION

Shot No.	Windshield No.	Speed (KT)	Location	Temperature	Remarks
1	1	250	Center line	Room	Required Protection
2	2	250	Secondary (Corner)	Room	Required Protection
3	3*	250	Worst	Room	Retention of Bird Impact Protection

All impact angles are 70 degrees measured from horizontal.

*After thermal pressure qualification.
(Reference 4.2.1 - SOW)

9.0 TESTING SCHEDULE

Testing schedule is mainly dependent on the delivery of composite reinforced frames from The University of Dayton. The following time slots have been reserved for bird impact testing:

Prototype testing Student W/S	May 1985
Prototype Testing Student W/S	July 1985
Flight Quality Student W/S	Sept. 1985
Flight Quality Instructor W/S	Sept. 1985
Flight Quality Student W/S	Nov. 1985
Flight Quality Instructor W/S	Nov. 1985

The impact testing of post thermal/pressure although not required, but desirable, is entirely dependent on the WPAFB time-frame for completing thermal/pressure testing.

10.0 DESCRIPTION OF TEST EQUIPMENT

The test equipment shall include bird carcasses, a bird propulsion gun, high-speed cameras up to 11,000 frames per second, and dual velocity measuring systems.

10.1 Bird Carcasses

The bird projectiles shall be previously frozen chickens thawed for 24 hours at 70 $\pm 5^{0}$F. The carcass weight shall be adjusted, if necessary, to meet the specified weight requirement. This adjustment shall be accomplished by trimming portion off of the extremities of the carcass or by adding a jel consisting of 98-percent water and 2-percent sodium carbox methylecellulose. Weight adjustments shall not exceed 10-percent of the final weight.

10.2 Velocity Measuring System

Bird velocities shall be measured by a photo electric system described in Appendix I Test Facility. The measured velocity may also be confirmed through the use of the high speed films. the films are marked continuously on one side by and LED light at a preset frequency; on the opposite side no mark appears until the bird package passes through a photo electric trigger system (event marker) which then triggers an LED light to a different preset frequency. A film rate of frames per second may be calculated using either one of the LED markers. By taking a pre-shot measurement from the event marker to the impact point and using the calculated frame, rate, a bird velocity can be calculated based on the number of frames counted from the first event marker to the frame showing

10.2 Velocity Measuring System (Continued)

the impact on the target point. Another way to verify the velocity is by using a preset or a measured velocity from the photo electric system and calculating the number of frames that should be exposed between the event marker and the impact point.

10.3 Equipment Accuracy

The accuracy of the velocity measuring equipment shall be within ±2 percent. Deviation in bird weight and impact angles shall not exceed those listed below:

Bird weight (4 lbs)	±2 oz
Windshield impact angle	±1 deg

10.4 Calibration

Calibration of all measuring and test equipment used in performance of these tests shall be of sufficient accuracies to substantiate validity of data to the accuracies specified in 3.5.3. All calibration shall be certified by an outside laboratory to N.B.S. standards.

10.5 Data Acquisition and Reduction Requirements

Test conditions, velocities, angles of impact, and a description of the impact and any damage to the test specimens shall be manually recorded for each bird strike test. Additionally, photographs shall be taken before, during, and after each strike. This data and any other information useful for substantiation shall be summarized, appropriately identified and correlated, and presented in the final test report.

11.0 TEMPERATURE DEFINITIONS

ROOM	Normal ambient temperature 70° ±5°F
LOW	-35°F outside ambient and 70°F inside ambient
HIGH	170°F outside ambient and 70°F inside ambient
	(Reference 4.2.1 - SOW).

12.0 ACCEPTANCE LIMITS

Windshield - The windshield shall be considered acceptable if, the tests meet the following criteria (Reference 4.2.1 - SOW).

There are no punctures of the transparency which result in a hole larger than 1.0 square inch.

There are no fracture patterns which would not resist a 4.0 pound bird impact at 130 knots (instructor windshield not required to take second impact).

There are no structural failures which would prevent continued safe flight.

There are no spall segments larger than .250 cubic inch ejected toward the pilot. If bird debris enters the cockpit area due to temporary deflection of the transparencies such debris will be of quantity, direction, and nature to preclude injury to the pilot which would prevent continuation of flight duties.

13.0 TEST SPECIMEN INSPECTION

Prior to testing each test specimen shall be conformance inspected to ensure conformity to specified requirements for dimensions, materials, and processes and to ensure the test specimens are representative of the actual production hardware. (Figure 7)

WINDSHIELD INSPECTION			WPAFB	
USAF T-38	P/N NP-158501	S/N		
ITEM DESCRIPTION	REQUIREMENT		CHECKED	ACTUAL
PPG 5300 Outboard Liner	.030 - .050 inch			
Polycarbontae Outboard Ply	.375 ± .038 inch			
PPG 112 Interlayer	.060 ± .006 inch			
Polycarbonate Inboard Ply	.187 ± .019 inch			
Hexcel Fiberglass O'bd. Retainer	.160 ± .016 inch			
Stainless Steel In'bd. Retainer	.035 ± .004 inch			
Nose and Sill Fairings - 6061T6 Al.	.100 ± .010 inch			
PPG 8500 Inboard Coating	.004 ± .002 inch			
Uralane 5738 Adhesive	A/R			
Urethane UR 2102 Sealant	A/R			
Sill Bushings 6061T6 Al.	1704-1			
Arch Bushings 6061T6 Al.	1702-5			
NAS 1580C3T-16	NAS Spec			
NAS 1580 C4T-30 and 34	NAS Spec			
Light Transmission	80% min.			
Haze	3% Max.			
Distortion	1/12 Student and 1/8 Instructor			
Deviation	.6 and 1.0			
Weight Assembled				

FIGURE 7

14.0 WINDSHIELD TEST

Four-pound bird carcasses at 70° ±5°F shall be propelled against the windshield assembly at the velocity and angles shown in Tables I, II, and III and at the locations shown in Figures 4 and 6. Any cracking, crazing, or other damage shall be documented. Each test shall be performed on a separate windshield system, except for the secondary shot on the student W/S at 130 knots (Reference 4.2.1 - SOW). PPG proposes that each of the student windshield systems be impacted with the second 130 knot shot before removing from the testing fixture or fuselage. This will cover all impacts to determine the most severe impact location and will not require re-installing a windshield system that has already been impacted and may have some structual damage making the re-installation difficult. PPG feels that the worst case condition of impact can be determined during prototype testing and secondary testing would be necessary only on that location in the flight quality phase. Again PPG recognizes that this test plan may be changed to allow multiple impacts on the same unit by agreement of both PPG and the WPAFB.

15.0 WITNESSING

WPAFB personnel shall witness all testing set forth in this test plan. Sub-contractors will also be permitted to witness testing if requested. PPG will notify WPAFB in sufficient time that witnessing arrangements can be made prior to start of testing.

16.0 DATA

16.1 Scope

The results of all testing and the new data accumulated in the performance thereof, including photographs, shall be part of the Final Development and Performance Report.

16.2 Format of test data sheets - All test data shall be recorded on appropriate test data sheets that include but are not limited to the following:

16.2.1 Windshield

Test Title

Date of Test

Windshield Name and Part No.

Test Facility

Ambient Temperature

Bird Weight

Speed Requirement

Actual Speed

Windshield Temperature Outboard Surface

Windshield Temperature Inboard Surface

Sketch of Windshield or Drawing No.

Test Results

Signatures

Identify Frames

Frame Reinforcement

Backup Parts by Serial No.

Canopy

17.0 NOTES

17.1 Reason for Tests

To investigate the physical damage caused to the windshield system as a result of collisions with birds during normal flight conditions.

17.2 Responsibility

PPG is responsible for the windshield and windshield system test fixture for the Bird Impact testing. WPAFB is responsible for providing backup canopys and the T-38 fuselage for flight quality testing.

18.0 GFE

The following list of GFE is in-house and usable for prototype and flight quality bird impact testing:

Quantity		Part No.
1	T-38 Front Fuselage	
10	Student W/S Front Arch Fairing	3-13008-3
2	Student W/S R/H Corner Fairing	3-13009-2
2	Student W/S L/H Corner Fairing	3-13009-3
30	Student W/S Locking Pins	5315-00-834-8410
2	Student W/S R/H Sill Fairing	3-13008-6
2	Student W/S L/H Sill Fairing	3-13008-5
14	Student W/S R/H Fame Hinge	3-13001-12
14	Student W/S L/H Frame Hinge	3-13001-11
1	Student W/S Frame (Master) S/N 1542	3-13001-507
1	Student W/S Frame (NASA) S/N 1306	3-13001-507
1	Student W/S Frame (Rebuilt) S/N 1584	3-13001-507
1	Student W/S Frame (Rebuilt) S/N 1585	3-13001-507
1	Student W/S Frame (Wellman) S/N 1570	3-13001-507
1	Student W/S Frame (Old-Style) S/N 1368	3-13001-507
1	Student W/S Frame (Wellman) S/N 1598	3-13001-507
1	Student W/S Frame (Northrop) S/N 1532	3-13001-507
1	Student W/S Frame (Northrop) S/N 1533	3-13001-507
1	Student W/S Frame (Northrop) S/N 1576	3-13001-507
4	Installation Part Kits	RK0149
2	Inflatable Rubber Seal	S12212
1	Instructor W/S Frame S/N 7859	3-13105-31
1	Instructor W/S Frame S/N 7858	3-13105-31
1	Instructor W/S Frame S/N 7851	3-13105-31
3	Instructor W/S Lower Riveted Frame	3-13115-15
1	Student Canopy (S/N 168)	3-13204-14 and Frame
1	Student Canopy (S/N 4050)	3-13204-14 and Frame
1	Student Canopy S/N 155	3-13204-14
1	Student Canopy S/N 170	3-13204-14
1	Student Canopy S/N 194	3-13204-14
1	Instructor Canopy	2-13309 and Frame From Fuselage
1	Instructor Canopy S/N 3233	2-13309 and Frame From Thunderbird

18.1 Additional GFE Required for Impact Testing

The following list of GFE is required to complete the prototype and Flight Quality Bird Impact Testing:

Second fuselage from AEDC already prepared for cameras.

Quantity		Part No.
4	Student W/S Frames	3-13001-507
4	Installation Part Kits	RK 0149

18.2 Additional GFE Required for Flight Quality Testing

The following list of GFE is required to complete the Flight Quality D/OT and E testing.

Quantity		Part No.
4	Student W/S frames	3-13001-507
8	Installation Part Kits	RK 0149
7	Inflatable Rubber Seals	S12212
10	Instructor W/S Frames	3-13105-31
10	Lower Riveted Frames	3-13115-15

Instructor W/S frames and lower riveted frames may be switched out from current aircraft. Three (3) seed frames would be desirable if switch-out is required.

APPENDIX

BIRD IMPACT FACILITY

PPG's new bird impact test facility located in Huntsville, Alabama has the following capabilities for impact velocities:

one pound bird from 72 knots to 413 knots
two pound bird from 29 knots to 413 knots
four pound bird from 58 knots to 751 knots
eight pound bird from 147 knots to 444 knots

The pneumatic cannon is approximately 56 feet in length of which 40 feet is barrel. the diameter of the barrel is a nominal 10 inches. Air to propel the sabot to the target is provided from a 106 cubic foot reservoir which gets its supply from a 200 psi compressor system (Reference Figure 3). Depending on the velocity required, there are four types of metal sabots to choose from. Each sabot is specifically designed to deliver the bird package down the barrel without damage or degradation during its acceleration (Reference Figure 6). Firing is accomplished through the use of Mylar diaphragms and a step chamber that is pressurized at one half the level of pressure used in the large reservoir (Reference Figure 4). The cannon is fired by exhausting the pressure in the step chamber which in turn ruptures the Mylar diaphragm retaining the pressure in the large reservoir. When the sabot reaches the end of the barrel, it is collected by a sabot stripper and spring system that absorbs the kinetic energy of the sabot (Reference Figures 5 and 7). The bird continues on to the

BIRD IMPACT FACILITY (Continued)

target that is usually located at a point approximately 10 feet distant. This distance can be shortened a few feet and/or lengthened several feet as need be.

The gun is fully adjustable in height from 61.5 inches up to approximately 9 feet. It is also adjustable for minor elevation changes at the muzzle. The height and elevation changes permit shooting on most fuselage configurations as well as test sample sizes of a standard 26x26 inch square. Frames are available for both bolted and clamped edge designs of this size. To insure that the test article is in it's proper position, the impact point is defined with a helium laser centered in the end of the barrel. Installation angles are verified with a precision clionmeter accurate to less than 1/4 of a degree.

Environmental conditioning of test transparencies is available in the form of heating blankets for elevated temperatures and GN2 as a cooling mode for low temperatures. In the case of low temperature conditioning, a "box" is built around the test article and remains in position until just seconds before impact at which point it is removed so as to not impede the bird velocity.

For test panels other than the above mentioned 26x26 inch size, a massive frame support system is available that can be adjusted for installation angles

BIRD IMPACT FACILITY (Continued)

from 25 degrees up to 85 degrees (Reference Figure 9). This frame can be easily modified to suit and/or support any type customer fixture that simulates the actual airframe. Where it is required, the floor space is sufficient to accommodate the front section of nearly any fuselage section. The initial design consideration for floor space was done with the front section of the Boeing 747 in mind.

High speed photography is accomplished with the use of 16 millimeter Hycam II cameras that are adjustable in speed up to 11000 frames per second. The lighting system and cameras are tied together electronically. When the "fire" button is depressed the lighting is switched on automatically and the cameras started. At a preset number of feet into the 100 foot spool of film, an internal camera speed sensor triggers a contact closure which then actually fires the cannon. This system not only provides excellent timing of lights, camera, action, but also permits the camera to attain the correct speed required for the test. Films can be viewed on a next day basis under most conditions but no later than two days after impact testing.

At this time only four channels of dynamic strain recording equipment are in house but these four channels are the "state of the art" type equipment.

BIRD IMPACT FACILITY (Continued)

The bird speed is measured with a system that makes our facility unique in that small particles or moisture clouds that precede the bird package do not trigger false readings of time and thus bad speed indication. The system is designed to operate only when 50% or more of the sensing light is obscured (Reference Figures 15 and 16). Bird speed is measured in three axis and averaged to compensate for minor deviations in flight pattern that the bird package might develop prior to impact. The frequency counters used to indicate the speed of the bird package over a measured distance of three feet are calibrated by an outside laboratory to N.B.S. standards. The referenced three foot distance is measured periodically by PPG but should never change unless new lights are installed which then could cause changes due to different filament positions within the lights (Reference Figure 17).

At present only two and four pound bird carcasses are in stock for test shooting but with sufficient notice arrangements can be made to accommodate other sizes. This description is not meant to cover or explain all of the capabilities of the impact facility now operational, but to provide an understanding of our general test capabilities.

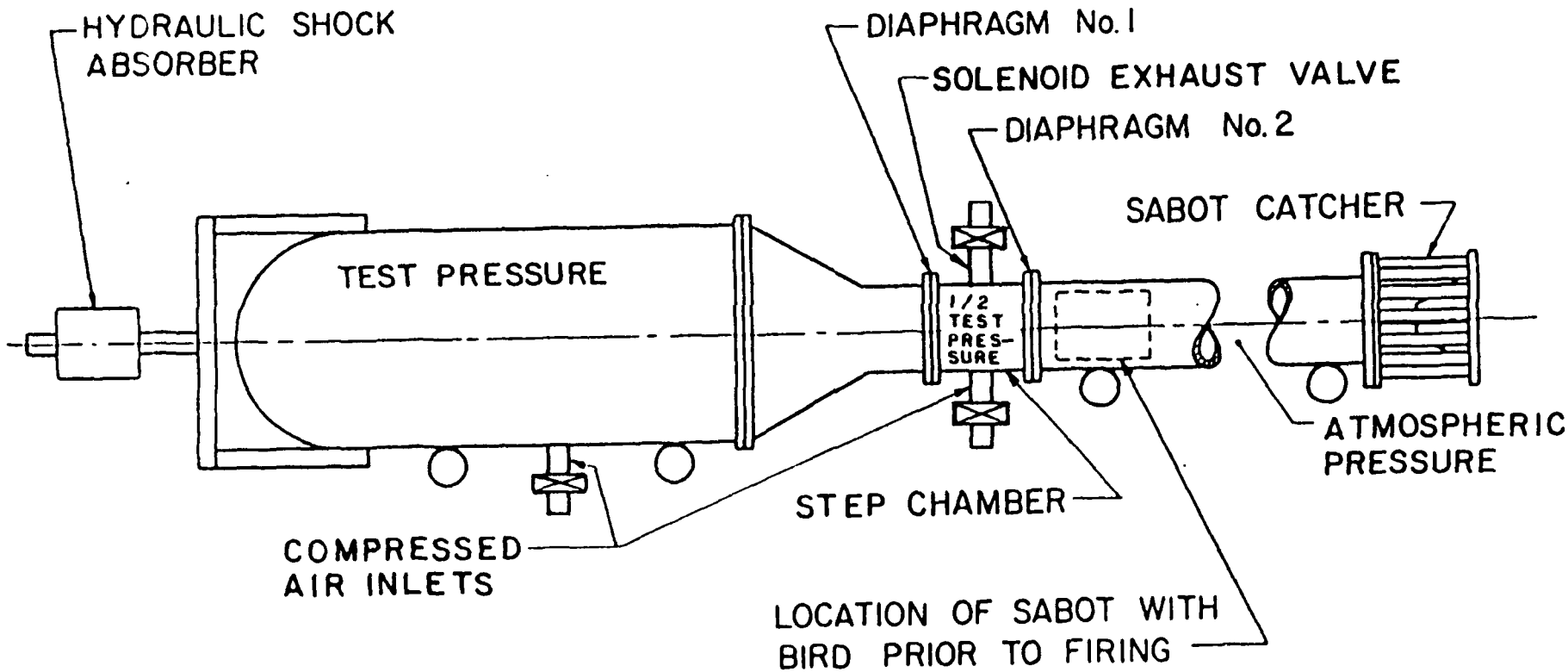


FIG. 3: DIAGRAM OF PNEUMATIC CANNON

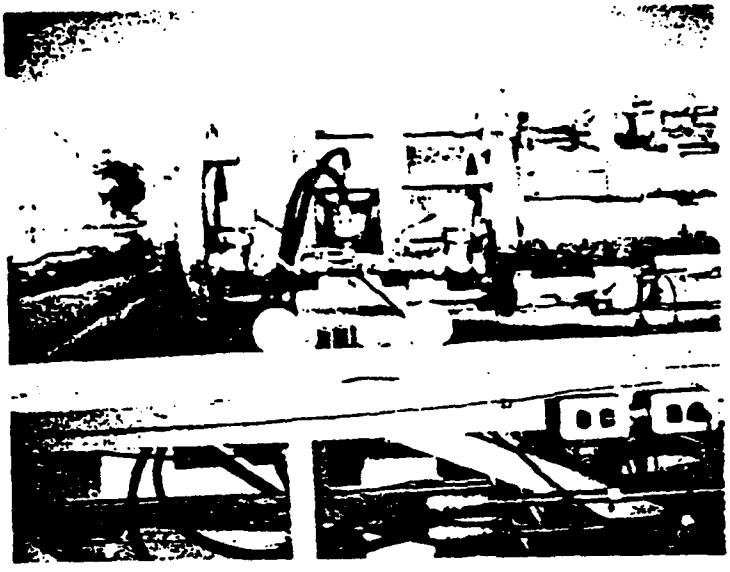


FIG. 4: STEP CHAMBER

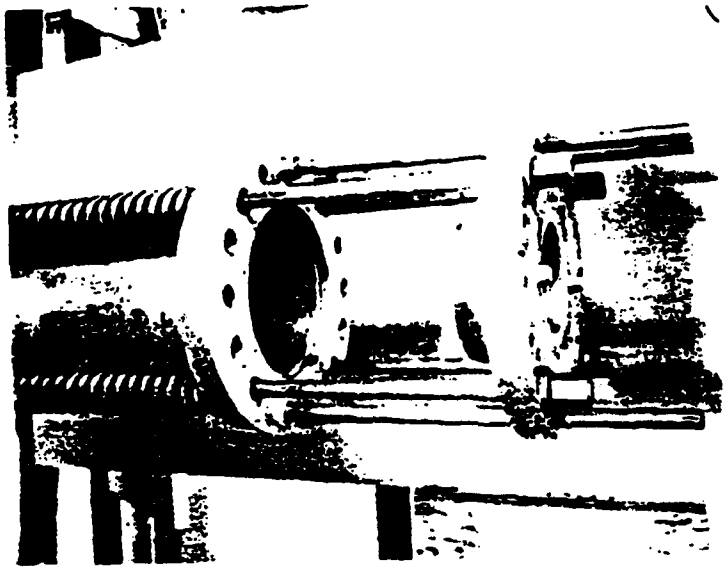


FIG. 5: SABOT ARRESTOR

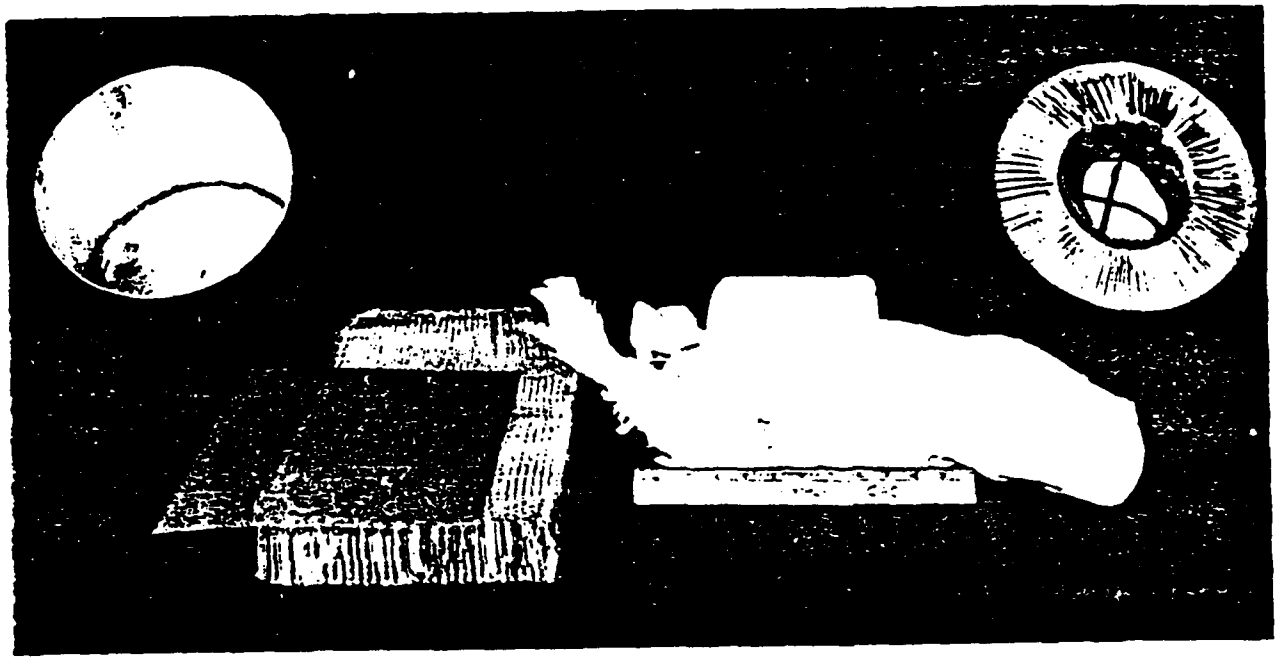


FIG. 6: SABOT COMPONENTS. BIRD PACKAGE AND ASSEMBLED SABOT WITH BIRD PACKAGE READY FOR FIRING

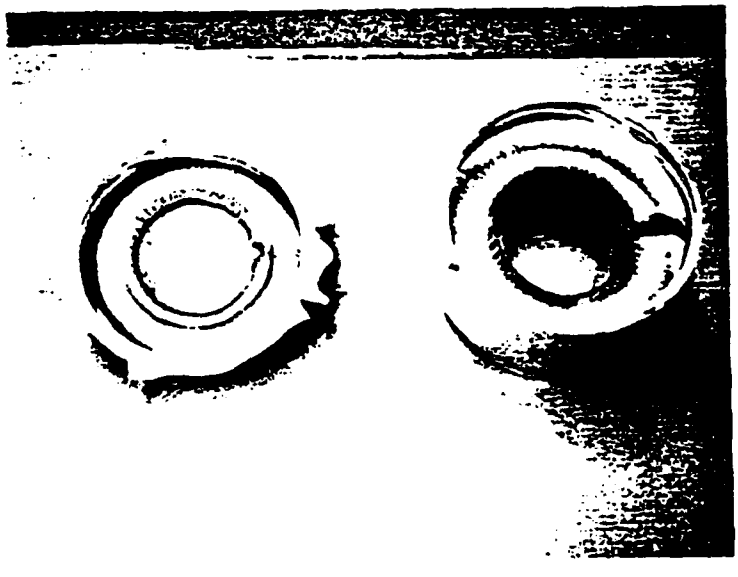


FIG. 7: EXAMPLES OF SPENT SABOTS

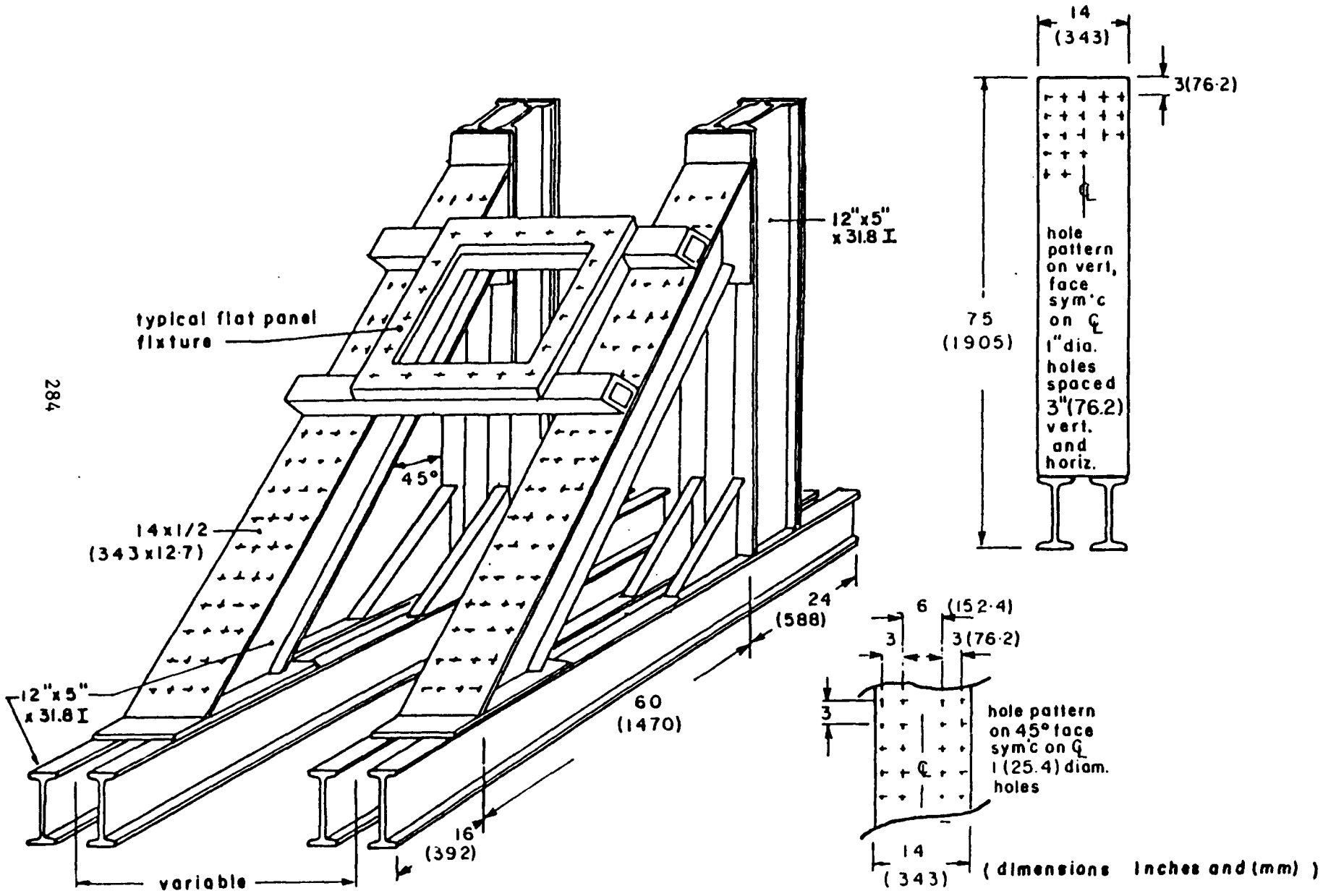


FIG. 9: SUPPORT FRAME

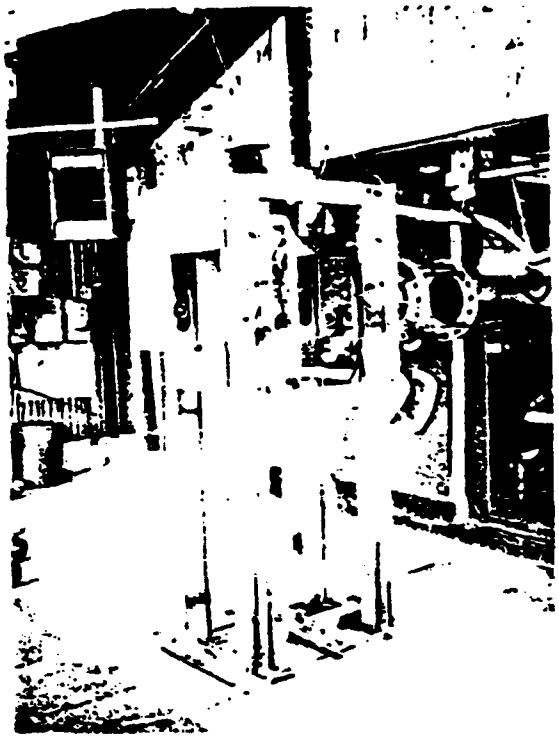


FIG. 15: TIMING FRAME

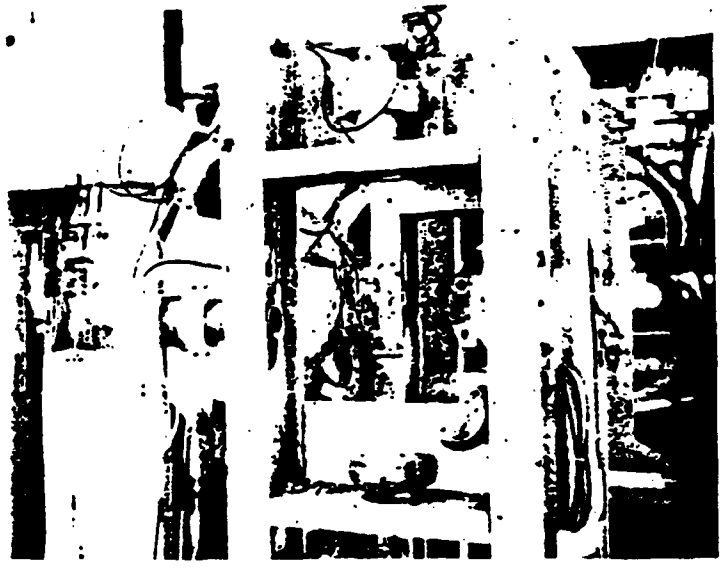


FIG. 16: DETAIL OF THE THREE "STOP" UNITS

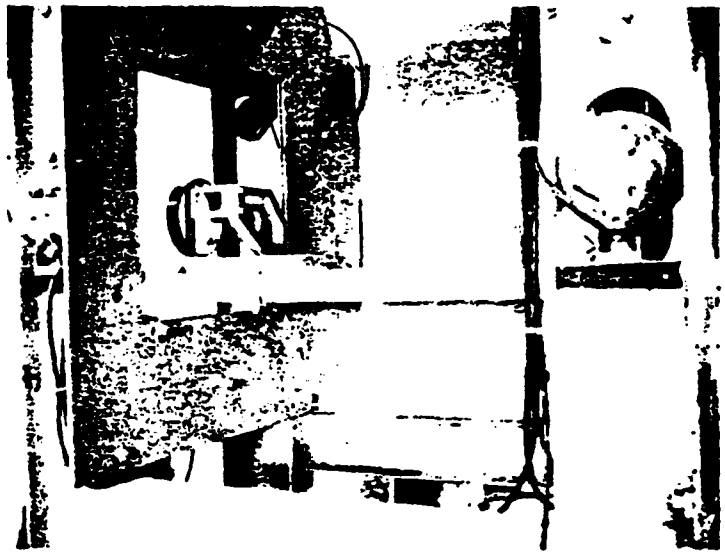


FIG. 17: TIMING INTERVAL APPARATUS SHOWN IN POSITION

☆U.S. Government Printing Office:1992—750-113/80006